

Biodiversity and the 2030 Agenda:

What pathway for zero net loss of
biodiversity in metropolitan France?



This report summarises the outcomes of an expert workshop held on 3 & 4 October 2019 at the *Institut de Recherche sur la Biologie de l’Insecte* of CNRS and the University of Tours. The workshop was prepared and facilitated by the French Hub of the Future Earth Secretariat and a Science Committee.

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Biodiversity and the 2030 Agenda: What pathway for zero net loss of biodiversity in metropolitan France?

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FORE WORD

> Biodiversity is at the core of human life, and ties in with numerous aspects of our ways of living through a complex system of interconnections. Almost everything we eat, drink and breathe is a product of ecosystems and their life forms. Food, safe water, human health, energy, the climate system, and a meaningful, enjoyable human life are inextricably linked to these ecosystems. Yet they are being steadily degraded and biodiversity is being lost faster than at any period in history, with potentially catastrophic cascading effects on human and planetary health.

> Any approach aiming to “bend the curve” of biodiversity loss needs to take this complex web of interconnections into account. If we want to be successful – and the accelerating rates of decline and loss call for an urgent response – we cannot continue to conserve and restore biodiversity in a siloed manner. Instead, we must analyse and exploit synergies and negotiate trade-offs with other natural and socio-economic objectives.

> The Covid-19 pandemic has highlighted the significance of the “one health” approach based on the collaborative efforts of multiple disciplines working on local, national, and global scales to attain optimal health for people, animals and our environment. It has also pointed up the importance of integrated approaches and systems thinking. A set of seemingly unrelated activities – including mining, infrastructure expansion, intensive agriculture and accelerating deforestation – have created a “perfect storm” for unleashing viral diseases that can spread from wildlife to humans.¹ On the bright side, the pandemic has been accompanied by a rapid and profound reshaping of public policies, individual behaviour, and personal life choices.

> Assessing interactions across the Sustainable Development Goals (SDGs) is the core aim of the *Science-Based Pathways for Sustainability* initiative, under whose aegis the biodiversity workshop was organised. The conclusions presented in this report highlight the challenges and potential solutions for tackling biodiversity loss in France in a holistic perspective and with integrated approaches. While focusing on biodiversity, the expert participants jointly assessed its interactions with urban sprawl, food security and agriculture, climate, energy

supply, inequalities, and marine systems. The outbreak of the COVID-19 pandemic in the months that followed has lent even greater importance to this workshop’s theme and ambition.

> Marking the end of the United Nations Decade on Biodiversity, 2020 is a milestone year for biodiversity protection. The UN Convention on Biological Diversity (CBD) is taking stock of its ten-year Strategic Plan, and despite some key progress, most of the Aichi Targets are beyond reach, especially those concerning indirect drivers of biodiversity loss. The new Post-2020 Global Biodiversity Framework, to be endorsed at the UN-CBD COP15, will be a defining moment. It follows on directly from the first IPBES Global Assessment, which points to the urgency of implementing transformative action while confronting the vested interests that oppose this radical change. At the European level, the *Green Deal* and its new *Biodiversity and Farm to Fork* strategies are a clear mandate from the Commission to act upon this urgent need to consider environmental issues as central to policy work across the board. More than ever before, implementing cross-sectoral, transformative change is now at the core of biodiversity perspectives. By bringing together experts in the interconnected systems of biodiversity change – policy-makers and researchers, private-sector stakeholders and the actors of civil society – and by exploring potential options for achieving biodiversity goals in France, our report aims at contributing to this transformative change. It also seeks to inform the discussion on the Post-2020 Global Biodiversity Framework, emphasising both the interconnectedness of the SDGs and the challenge of designing complex pathways to achieve these goals from both national and sub-national points of view.

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¹ Settele, J., Díaz S., Brondizio E., Daszak P. (2020): COVID-19 Stimulus Measures Must Save Lives, Protect Livelihoods, and Safeguard Nature to Reduce the Risk of Future Pandemics. <https://ipbes.net/covid19stimulus>

BIODIVERSITY WORKSHOP:

Context, objectives and methodological approach

1.1 Participatory and normative scenarios to analyse interactions between the SDGs and transformations

► The workshop held in Tours in October 2019 forms part of the *Science-Based Pathways for Sustainability* initiative of the *Future Earth* international research programme.² This initiative aims to promote integrated and forward-looking approaches to the Sustainable Development Goals (SDGs). It mobilises the broad range of expertise needed to build scenarios and pathways for attaining the “green” SDGs (6: Freshwater, 13: Climate, 14: Oceans, 15: Biodiversity) by exploring their interactions with the other SDGs on different spatial scales. The purpose of this initiative, based on a series of workshops, is to identify new questions and research practices to further our understanding of socio-ecological systems and inform public debate and policy. The workshops provide an opportunity to explore different options for advancing towards the environmental goals of the 2030 Agenda, to identify the main uncertainties surrounding these options, their potential synergies and trade-offs with the other SDGs and the social transformations that they entail.

► The biodiversity workshop applies a methodological approach based on three sets of studies: (i) the literature on participatory development of qualitative scenarios; (ii) assessments of the interactions between the SDGs at different spatial scales; and (iii) analyses of societal transformations for sustainable development.

► The potential of adopting a normative (or target-seeking) scenario approach for analysing transformation towards sustainability has been extensively explored in the literature. In contrast to exploratory scenarios, which consider several possible futures based on assumptions about the evolution of direct and indirect drivers, normative approaches work backwards from a particular desirable future to the present in order to analyse the feasibility of achieving that future, as well as the pathways for reaching it (Robinson, 2011, 2003, 1990; Dreborg, 1996). The normative approach is recognized as a process enabling actors engaged in such exercises to set priorities and rank solutions in order to reach objectives, and – as such is particularly suited to developing pathways for achieving the SDGs. Indeed, as policy development increasingly relies on the establishment of environmental targets such as those found in the SDG framework, the need for normative, goal-oriented approaches has emerged (Kanter et al., 2016). In the *Pathways* initiative the purpose

of designing normative scenarios is not prescriptive but heuristic. It is assumed that a desirable future is possible; building scenarios that lead to this future enables a better and shared understanding of the meaning of such an achievement, with the dilemmas, the trade-offs and the main challenges it entails, as well as the transformations and discontinuities that it implies (Paillard et al., 2014).

► Participatory approaches are often applied to normative scenario design to promote mutual understanding and to co-produce new knowledge (Kishita et al, 2017). In this regard, the involvement of participants from different disciplines and sectors broadens the knowledge base, but also allows for the integration of divergent values and perceptions (Durham et al., 2014). Participatory approaches also bring value by integrating diverse stakeholders able to disseminate the scenario outcomes in relevant networks (Bohunovsky et al., 2011), and by fostering “ownership” of the project by those likely to benefit from or be affected by the project outcomes (Durham et al., 2014). Interdisciplinarity and stakeholder engagement are especially relevant when designing pathways for sustainability, as addressing “wicked” challenges such as climate change or biodiversity erosion requires the involvement of actors from different sectors, operating at multiple levels with potentially divergent interests (Vervoort et al, 2014). This balanced involvement remains one of the main challenges of participatory approaches, as an equal representation of all relevant stakeholder groups is impossible. Moreover, the literature on participatory processes highlights the need to take account of the complexity of social contexts, power asymmetries in particular, in which participatory processes are conducted (Barnaud and Van Paassen, 2013). In the *Pathways* initiative, key stakeholders from academia, policy arenas, civil society and the private sector are involved in the development of pathways that are grounded in the participants’ scientific and practitioner expertise but also in their values and visions for the future, with the aim of fostering stakeholder dialogue and debate.

► While scenario development is often used to formulate sector-specific pathways, for instance for energy (Kishita et al, 2017), cities (Bibri, 2018), or food security (Erb et al., 2016; Vervoort et al, 2014), the *Pathways* initiative adopts a cross-sectoral approach in order to analyse interactions between SDGs. Although the Agenda 2030 presents SDGs independently, it also highlights that they are indivisible. Indeed, SDGs are interdependent in social-ecological systems, implying that progress on one can

² <https://futureearth.org>

impact others (Singh et al., 2018). Achieving the SDGs requires recognition of the complex spatial and temporal dependencies that exist between them, and understanding the interactions among SDGs is key to ensuring that progress made in some sectors does not hinder progress in others (Nilsson et al., 2016). Various methods have been used to explore the interlinkages, such as the International Science Council's seven-point scale (ISC, 2017) or Singh's framework which classifies interactions in subcategories such as co-benefit/trade-off/neutral; prerequisite/optional; context dependent/independent (Singh et al., 2018). For the *Pathways* initiative, scenario development is coupled with an SDG interaction assessment in order to identify pathways that take into account synergies and tradeoffs between SDGs. Moreover, human-environment linkages are emphasised by including both "green" and "social" SDGs in the analysis (Scharlemann, 2020). Relevant interactions are analysed across SDGs and across scales. Indeed, national or local pathways are part of larger, interconnected regional and global systems (Friis et al., 2016; Eakin et al., 2014, Liu et al., 2013; Seto et al., 2012).

➤ Finally, the *Pathways* initiative is based on transformation analysis. This line of inquiry aims at identifying "fundamental changes in structural, functional, relational, and cognitive aspects of socio-technical-ecological systems that lead to new patterns of interactions and outcomes" (Patterson et al., 2017). This field of study includes analyses of socio-technical transitions for sustainable modes of development (Smith and Stirling, 2010; Kemp and Rotmans, 2005; Geels, 2002), studies of transition management (Loorbach, 2007) or of transformative adaptation (Colloff et al., 2017) and transformative governance (Chaffin et al., 2016). These analyses seek to understand the characteristics and processes of societal change that lead to more sustainable futures, focusing on pathways and their sustainability, and the structures, strategies and actors which drive the transformation of socioecological systems.

1.2 Pathways workshop on biodiversity in metropolitan France

➤ The Biodiversity workshop brought together around 20 participants in Tours (France) in October 2019.³ It aimed to build a scenario for attaining the objective of "zero net loss of (terrestrial) biodiversity in metropolitan France by 2030". The construction of the scenario and its pathway⁴ took into account the potential synergies and trade-offs between this "central" objective associated with the SDG on biodiversity, and other SDGs. For the participants, this involved weighing the relative importance of the various goals through a deliberative process. In the absence of consensus, participants could choose to construct several scenarios. Participants were also free to redefine the central objective if its achievement meant downgrading other goals to which participants collectively decided to accord greater value

➤ The task of constructing the biodiversity scenario included the workshop itself, but also its preparation and the work of synthesising and consolidating the workshop findings (Figure 1.1). Prior to the workshop, a scientific committee was asked to specify the workshop's geographical scope⁵ and to define the central objective that would be proposed to participants. The aim was to choose a normative objective shared by the scientific community. The objective chosen by the scientific committee was "zero net biodiversity loss". This is accepted in both scientific and political spheres and is incorporated in the national biodiversity strategy for 2030 (MTES, 2018). The 2030 time horizon, which matches that of the SDGs, is very close and leaves little time to imagine a future that is potentially radically different from today. To lift this time constraint, the scientific committee defined a vision for 2050, considering the 2030 horizon as a step towards realising a more ambitious vision. The 2050 vision of the Convention on Biological Diversity (CBD) of "living in harmony with nature" was chosen. It states that "by 2050, biodiversity is valued, conserved, restored and wisely used, maintaining ecosystem services, sustaining a healthy planet and delivering benefits essential for all people" (CBD, 2018).

➤ The scientific committee then analysed the system whose possible future(s) were to be explored by the workshop participants via the construction of a scenario. This involved analysing past and current trends of biodiversity loss in France and of its drivers. This analysis is synthesised in section 2 of this document. Moreover, the scientific committee selected the SDGs on which the workshop would be focused in addition to SDG 15. Two sets of SDGs were identified (Figure 1.2). The first

³ The Biodiversity workshop is the first in a series of three workshops held in France. The two others are focused, respectively, on freshwater and land.

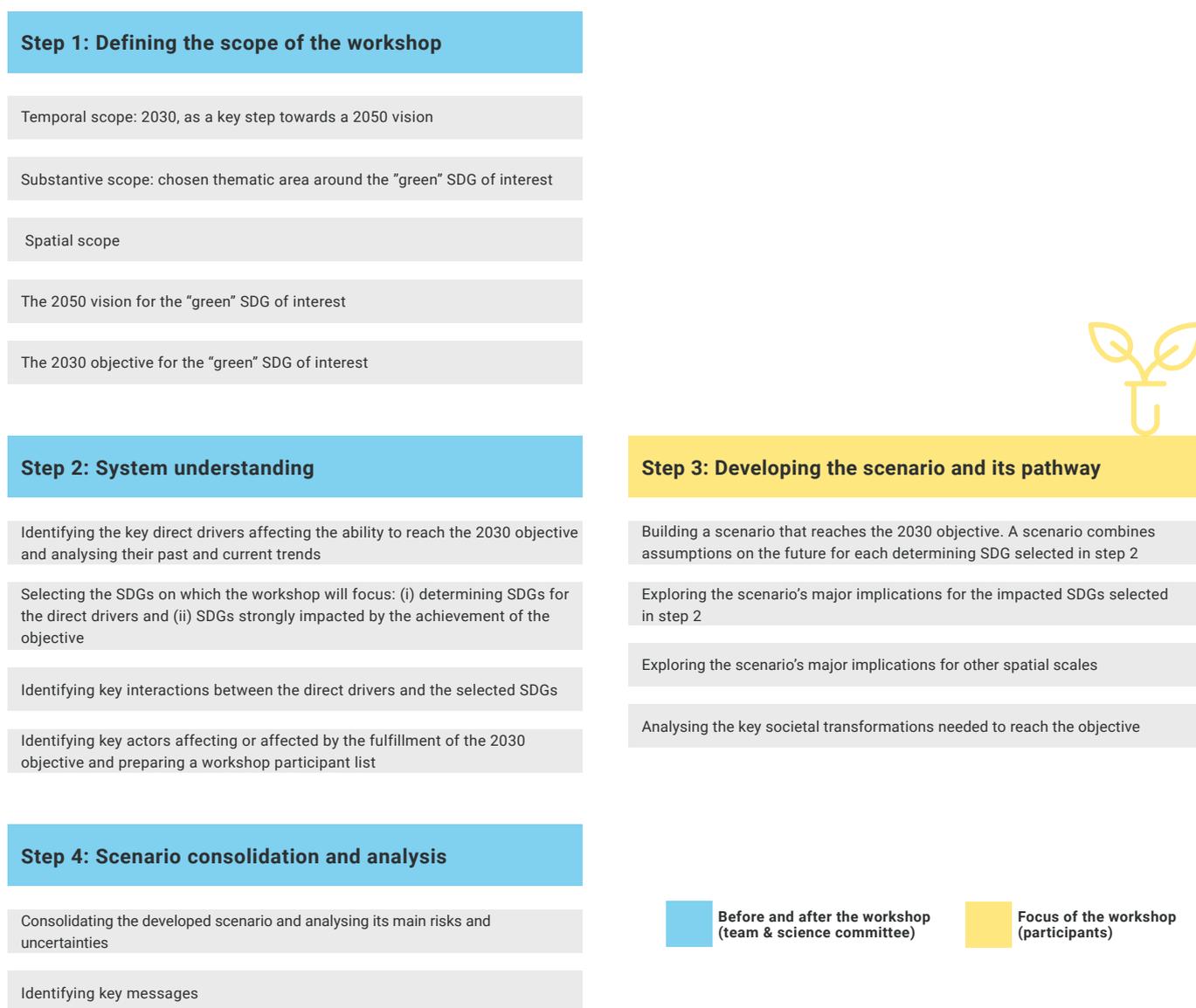
⁴ A scenario describes a plausible future in all its biophysical and societal dimensions and the pathway for attaining it. A pathway consists of the transformations, steps and actions required to realise the scenario.

⁵ The scale decided by the scientific committee was that of metropolitan France (mainland France and Corsica), given that the challenges of biodiversity in the overseas territories call for a specific dedicated approach. An analysis focused on the overseas territories will complement the outcomes of the Biodiversity workshop.

includes the SDGs with the strongest potential impact on the evolution of direct drivers of biodiversity loss⁶ in metropolitan France by 2030. The second includes the SDGs for which reaching this objective will have major implications. This choice of SDGs, and hence of workshop themes, served to define the list of participants, drawn up on the basis of three principles. First, the workshop was to include representatives of the main areas of scientific and field expertise necessary for analysis of the interactions between the selected SDGs. Second, it was to include non-academic actors whose strategies play a key role in achieving the objective.⁷

Third, participant numbers being limited, not all fields of expertise and all stakeholders concerned by the challenges of biodiversity in metropolitan France would be represented. The aim was not so much to be exhaustive and representative as to achieve a diversity of expertise and visions for the future.

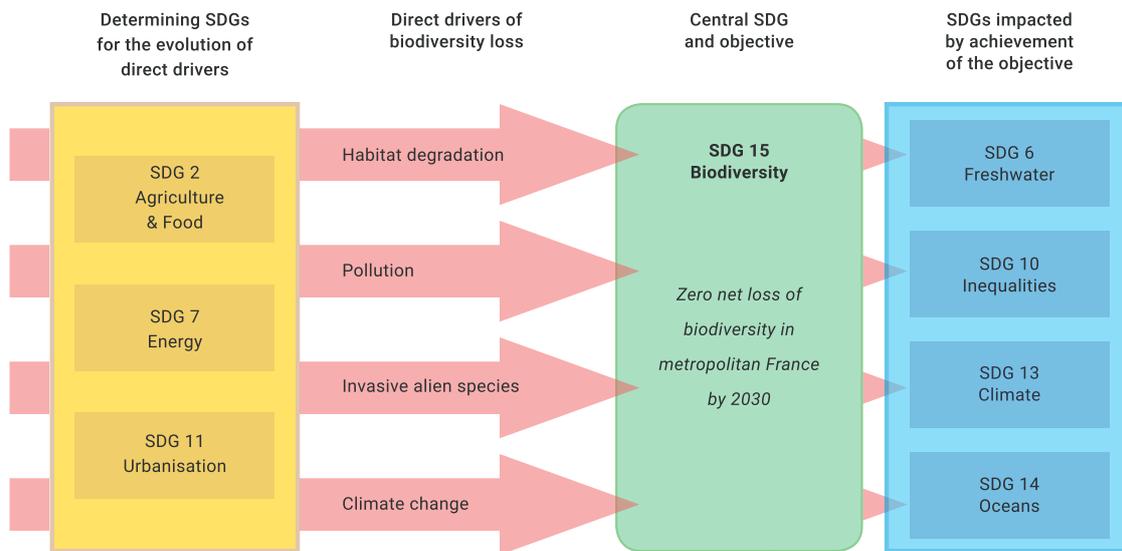
Figure 1.1
The steps of the Biodiversity scenario development



⁶ We use the distinction made by IPBES between direct and indirect drivers of biodiversity loss. “The direct drivers of change in nature with the largest global impact have been (starting with those with most impact): changes in land and sea use; direct exploitation of organisms; climate change; pollution; and invasion of alien species. Those five direct drivers result from an array of underlying causes – the indirect drivers of change – which are in turn underpinned by societal values and behaviours that include production and consumption patterns, human population dynamics and trends, trade, technological innovations and local through global governance” (IPBES, 2019).

⁷ The scientific committee was eager for both researchers and non-academic stakeholders to be equally represented. A slightly higher proportion of researchers having responded positively to the invitation, the workshop brought together 13 researchers and 7 non-academic stakeholders.

Figure 1.2 Objective of the scenario, direct drivers of biodiversity loss and studied SDGs

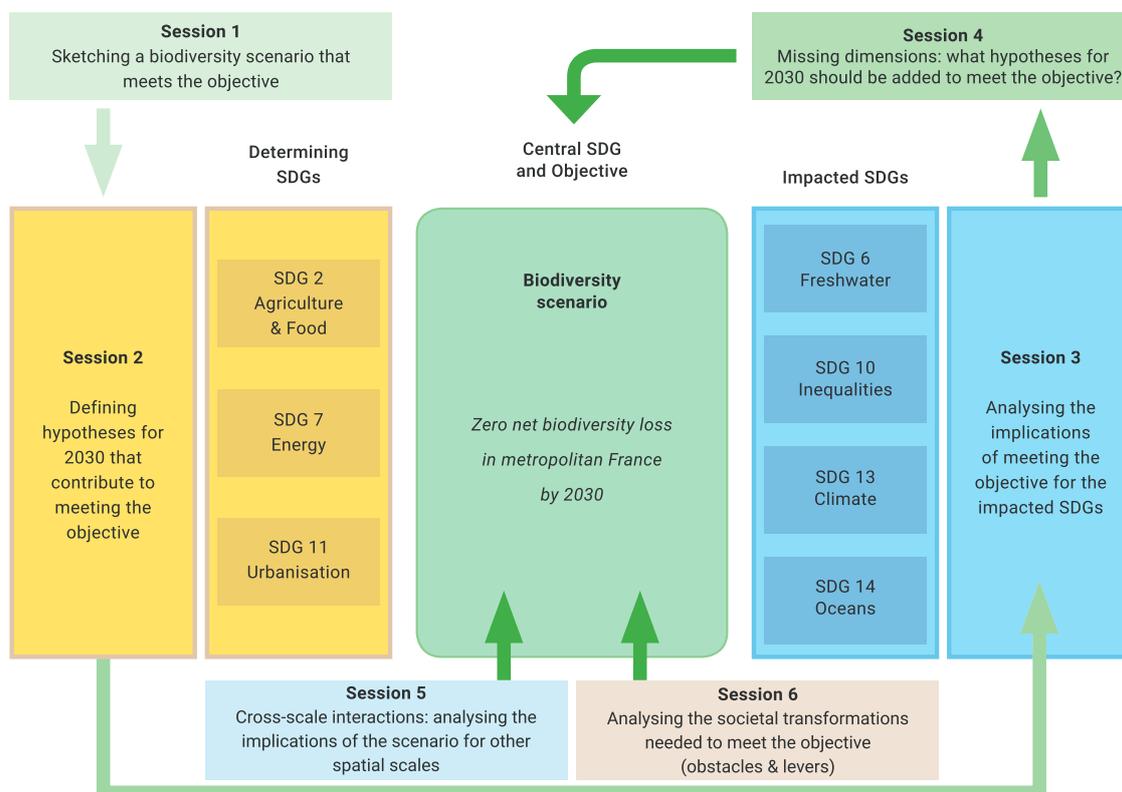


Note : Drivers related to changes in land use and direct exploitation of organisms are grouped in the habitat degradation driver.

> The workshop was divided into six sessions (Figure 1.3). During the first session, participants defined an outline scenario, which is presented in section 3. They refined it over the next sessions by analysing the main synergies and trade-offs between the central objective and the selected subset of SDGs (Sections 4 to 7). In this way, the outline scenario initially based on assumptions centered on biodiversity was gradually fleshed out with assumptions of change relative to the other SDGs. During the fourth session, participants identified missing dimensions of their scenario. Certain assumptions were not consensual or participants considered that they lacked the necessary expertise to make such assumptions. The assumptions on which participants did not arrive at a conclusion revealed controversies, often linked to conflicts between different goals, or issues calling for further research to better understand the implications of pursuing the “zero net biodiversity loss” objective for other SDGs. The scenario and its assumptions, as well as its main uncertainties and missing dimensions are presented in section 8.

> During the fifth session, participants identified the main implications of their national scenario for regional and international scales. One aim was to understand how pursuing the “zero net biodiversity loss” objective at the scale of metropolitan France would weaken or strengthen the capacity of actors at other spatial scales (country, world regions, planet) to achieve the SDGs. During this step, presented in section 9, participants could adapt and enhance their scenario to take account of scale interactions.

Figure 1.3 The sessions of the Biodiversity workshop



> The pathway associated with the scenario was discussed in the sixth and final session presented in section 10. Participants analysed the societal transformations needed to achieve the scenario using the *vrk* (Values, Rules, Knowledge) framework developed by TARA (Transformative Adaptation Research Alliance).⁸ Transformations are initiated through decision-making processes in the social, economic or political spheres. These processes are constrained by decision-makers' preferences, the institutional context in which they work and their understanding of the world (Lavelle et al., 2019; Colloff et al., 2017). Using the *vrk* framework, participants sought to identify the components of the decision-making frameworks that would make it possible to redefine the problems considered in the decision-making process, to uncover new options and ultimately to realise the transformations that they considered key to realising the biodiversity scenario.

⁸ <https://research.csiro.au/tara/>

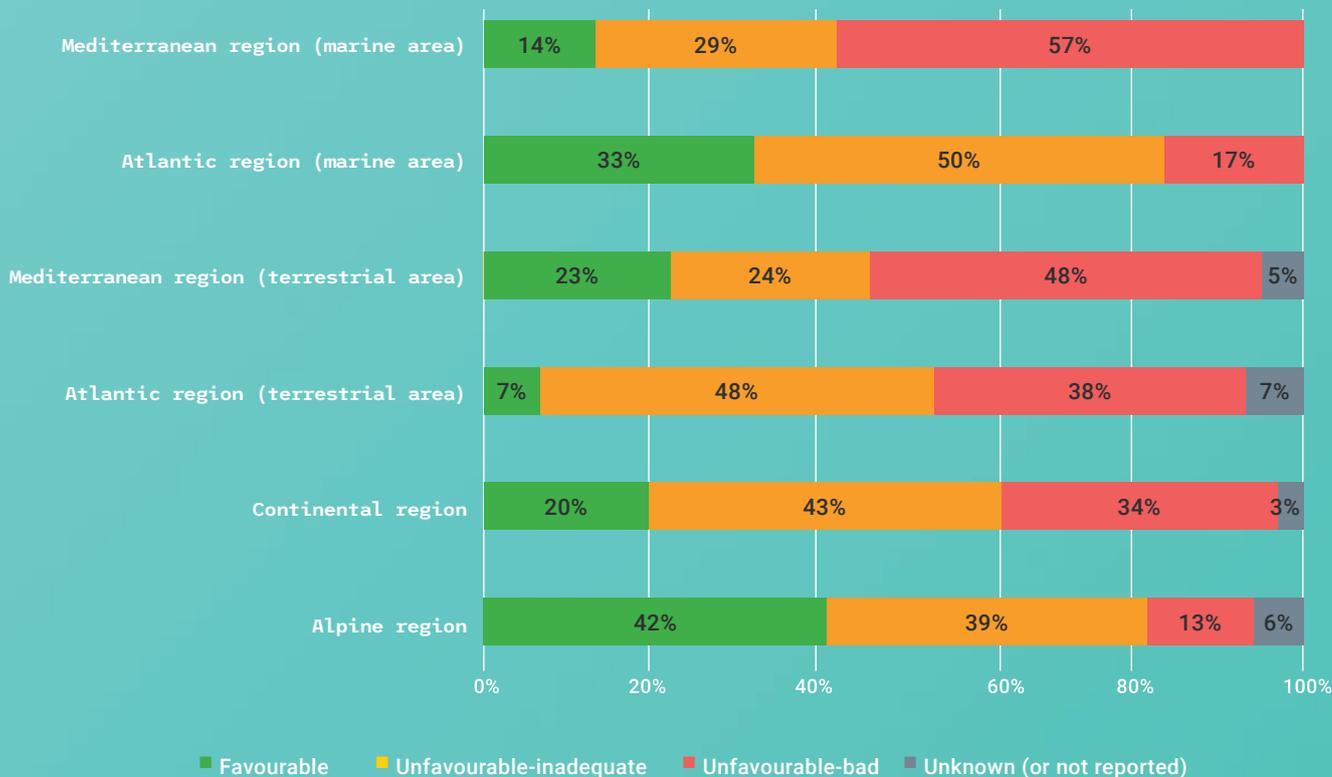
2.

MAIN CHALLENGES AND DRIVERS OF BIODIVERSITY LOSS IN FRANCE

► France is a “megadiverse” country, with an exceptionally rich cultural and natural heritage. Mainland France contains four biogeographic regions (Continental, Alpine, Mediterranean and Atlantic) and its overseas territories are spread out across multiple latitudes. France is home to five WWF and IUCN-recognised biodiversity hotspots, of which four are in the overseas territories where biodiversity is highly vulnerable due to their insular geographic characteristics. For example, the red list of flowering plants and ferns in the island Réunion includes 49 species that are already extinct and a further 275 being threatened with

extinction, out of a total of 905 plant species analysed (CBD, 2019a). In mainland France, as shown in Figure 2.1, biodiversity is highly vulnerable as well, with the majority of habitats found to be in either an unfavourable or poor state (ONB, 2019). The main drivers of ecosystem vulnerability and biodiversity loss on a national level are the same as on a global level: land-use change, anthropogenic pollution, climate change and greater incidence of invasive alien species (CBD, 2014).⁹

Figure 2.1 State of conservation of habitats of communal interest by biogeographic region in metropolitan France



Note : Results show all types of habitats combined. Source : MNHN (SPN), 2013

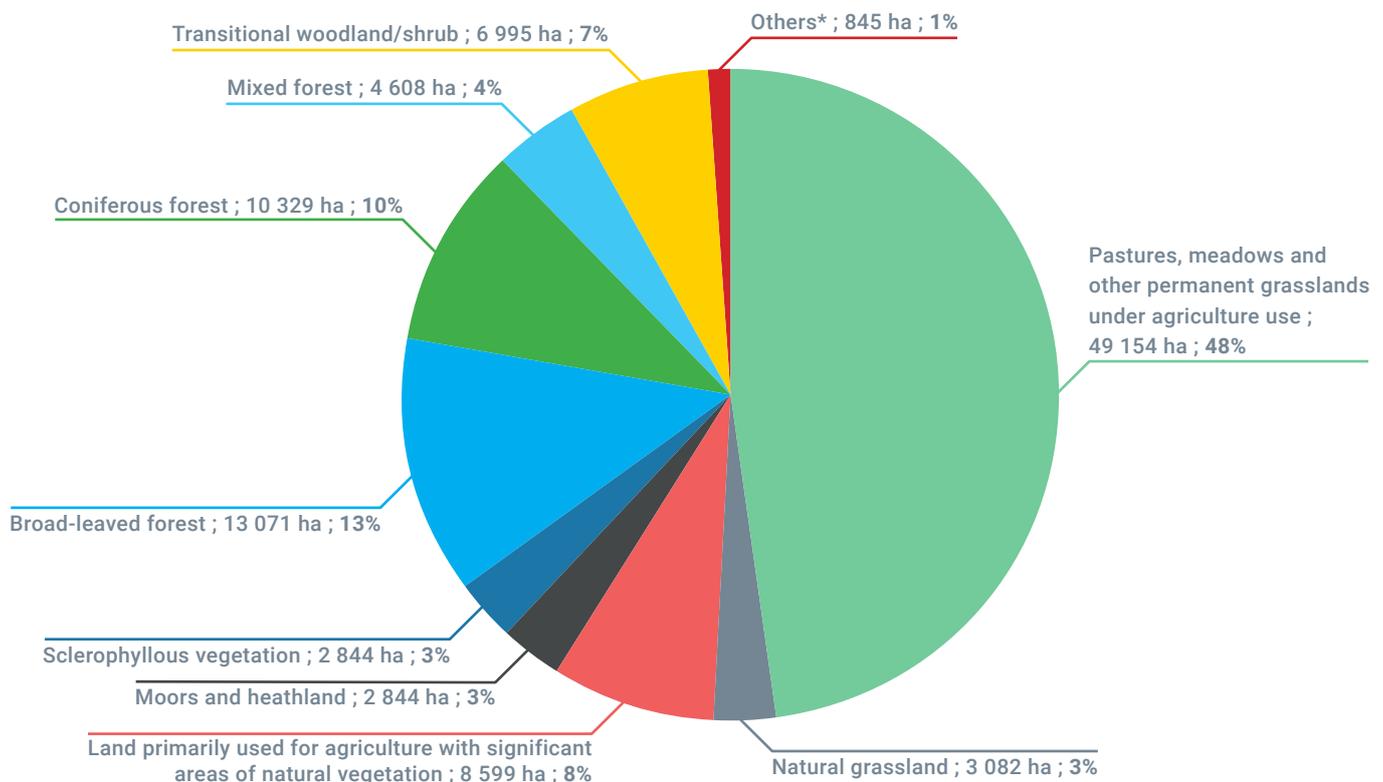
⁹ A literature review on the current status of ecosystems and drivers of biodiversity loss in mainland France, prepared ahead of the workshop, is available at <https://futureearth.org/initiatives/earth-targets-initiatives/science-based-pathways/>

2.1 Land use and land cover change

> Land-use and land-cover change diminish biodiversity through habitat degradation, fragmentation and loss, and are expected to remain a leading cause of biodiversity loss (IPBES, 2019; Bartlett et al., 2016). Key drivers of land-use and land-cover change in France include agricultural activities and soil impermeabilisation due to urbanisation. Intensification of agriculture in France has resulted in genetic vulnerability and diversity loss in agricultural ecosystems (CBD, 2008). Land take, either for infrastructure like roads or for constructed environments like housing or agricultural buildings, has significant adverse impacts on ecosystem health and has seen an increasing trend in France, as in the rest of Europe. As shown in the Teruti-Lucas survey, the total artificial land area¹⁰ has grown from 3 million hectares

in 1981 to 5.1 million hectares in 2014. According to the CORINE Land Cover dataset of 2012, France's land take of 5.3% of the total metropolitan territory is slightly higher than the European average of 4%. Besides direct habitat degradation, fragmentation and loss caused by land take (Figure 2.2), the urban heat island effect and urban runoff also affect species' health and vulnerability. Furthermore, urban land cover sprawl adversely impacts bordering habitats, with noise pollution from roads altering species' behaviour and activity patterns (Forman, 2000).

Figure 2.2 Natural areas destroyed by land take between 1990 and 2012 in metropolitan France



Note : *Others : Beaches ; Sand dunes ; Bare rocks ; Sparse vegetation cover ; Inland marshes ; Maritime marshes ; Salt marshes.

Source : UE-SOeS, CORINE Land Cover

¹⁰ Artificial land surface includes: urban fabric ; industrial, commercial and transport units ; mine, dump and construction sites ; artificial non-agricultural vegetated areas.

2.2 Pollution

> Pollution comes in many forms (air, light and noise pollution, soil contamination and untreated waste) and can have varying effects on biodiversity. Agriculture, industries and urban areas are all major sources of anthropogenic pollution. Pesticides used by agriculture are a major source of biodiversity decline in agricultural landscapes. Pollutants can directly affect ecosystems, and indirectly threaten biodiversity through climate change impacts. Air pollution can affect biodiversity and the functioning of an ecosystem by changing population genetic diversity and/or reducing vegetation production and the reproductive potential of populations (Barker and Tingey, 1992). The widespread use of artificial lighting, especially at night-time, can affect the circadian rhythms of animals, insects and plants (Hölker et al., 2010). Man-made sounds are another pollutant affecting ecosystem health by inhibiting animal communication and negatively affecting their reproduction and usage of space (Drolet et al., 2016; Sun and Narins, 2005). Nutrient pollution in soil ecosystems can impact plant species diversity and indirectly affect dependent fauna. Northern France, for example, was identified as one of the regions where biodiversity was at risk, with nutrient pollution from agriculture being one of the key drivers (Jeffery et al., 2010).

> Inland waterways are threatened by the dispersion of agricultural inputs like pesticides, fertilizers and the discharge of partially treated wastewater. In 2015, for example, only 44% of water bodies analysed in mainland France were in a “good ecological state”, with around 69% of groundwater bodies being in a “good chemical state” (Blard-Zakar and Michon, 2018). The primary drivers of the pollution of inland aquatic environments are nitrate and pesticide pollution related to agricultural practices. Industrialisation and urbanisation also represent a major source of contamination and pollution of the groundwater and soil ecosystems (Panagos et al., 2013).

2.3 Climate change

> Climate change represents an existential threat to ecosystems and biodiversity, as the effect of higher mean temperatures, extreme weather events, precipitation volatility and resulting erosion is expected to adversely impact the health of ecosystems in Europe and around the world (Stocker et al., 2013; Trömel and Schönwiese, 2007; Meehl et al., 2000). The Intergovernmental Panel on Climate Change’s (IPCC) climate simulations point to an increase in precipitation for northern European areas and likely decreases for southern European and Mediterranean basin regions (Jacob et al., 2014). France’s geographical location between northern and southern European regions makes its precipitation trends difficult to predict. Still, generally higher air temperatures could increase

evapotranspiration and thus create a soil water deficit which would place additional pressure on water resources through increased irrigation needs (Calvet et al., 2008). With seven of the ten hottest years on record since 1901 in the last decade, and with temperatures that have already risen by 0.9 degrees Celsius in the last century, climate change and its impact can already be felt in France. Over the whole metropolitan territory (mainland France and Corsica), minimum temperatures have gone up more than maximum temperatures and average temperatures in southern regions have seen larger increases compared to northern areas (EEA, 2015).

> Thuiller et al. (2005) showed that more than half of the species they studied could be vulnerable to or threatened by climate change by 2080. Expected species loss is highly variable across scenarios (27 – 42% averaged over Europe) and across regions (2.5 – 86% averaged over scenarios). French Alps and Mediterranean environmental zones are among the most sensitive regions in Europe. Mountain ecosystems are particularly at risk from climate change effects in France. In the Mont Blanc massif, for example, there were 25% more snow-free days at an altitude of 2500m in the 2005-2015 period than in the 1964-1975 period (CREA Mont-Blanc, 2019).

2.4 Invasive alien species

> The introduction of alien species, defined by the CBD as a “species whose introduction and/or spread threatens biodiversity”, has risen in the past two decades through trade and human transport (CBD 2019b; Hulme, 2009). Anthropogenic influences in ecosystems can render them vulnerable to invasive alien species, especially if these result in reduced competition or competitive ability of native species. For the majority of biological groups, metropolitan France has the highest number of invasive alien species in Europe, with 1,379 species of exotic plants and 708 species of exotic fauna (such as the louisiana crawfish, coypu, or bullfrog) listed by the National Inventory of Natural Heritage (DAISIE, 2009). The 1979-2018 period saw a notable increase in the presence of alien invasive species in all metropolitan French departments compared to the 1949-1978 period (ONB, 2018). The French overseas territories are particularly vulnerable to native biodiversity loss to invasive alien species owing to their unique geographical locations.

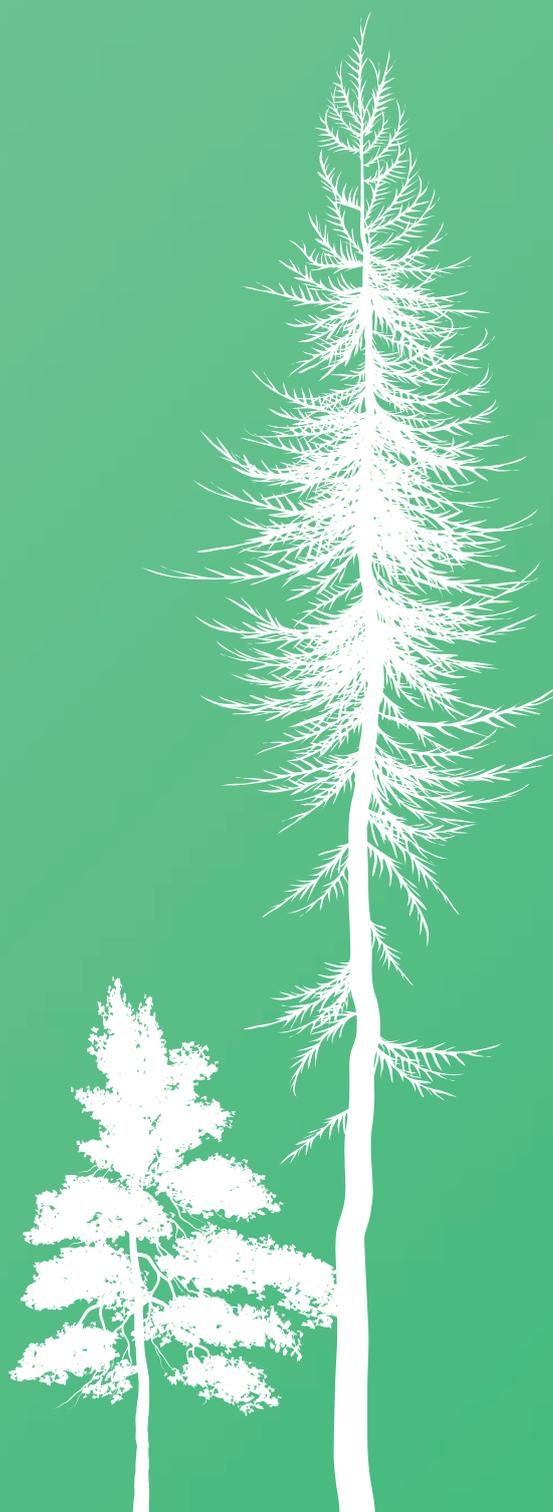
> Climate change has been shown to exacerbate the problem of alien invasive species; one example is the significant change in insect distribution over the past 30 years. In parallel, the success of invasive alien species is partly attributable to land-use and land-cover change. For example, it has been observed that imported fire ants (*Solenopsis invicta* Buren) are much more likely to adapt and thrive on roadsides or in agricultural environments than in intact closed forests (CBD, 2019b).

OUTLINE SCENARIO FOR ZERO NET BIODIVERSITY LOSS

► *Land sparing* and *land sharing* (LSLS) are two frequently contrasted biodiversity protection strategies. The opposition between them was explored for the first time in 2005 in order to assess the capacity of different farming landscapes to maintain the diversity of wild species (Green et al., 2005; Balmford et al., 2005). Under the *land sparing* strategy, some areas of land are used for intensive agricultural production while others are set aside to maintain biodiverse natural environments. Under *land sharing*, on the other hand, land use is more diverse and the objectives of biodiversity protection and food production are combined. The original aim of this model was to quantify the impacts of different agro-environmental systems on biodiversity by comparing the population density of each species as a means to estimate habitat quality (Phalan et al., 2011; Hodgson et al., 2010; Green et al., 2005). Initially used to assess biodiversity conservation gains on a small spatial scale, the LSLS model has since been applied on a larger scale to measure the impact of various spatial configurations on biodiversity conservation (Grau et al., 2013), including in forests and urban environments (Phalan et al., 2011; Perfecto and Vandermeer, 2010; Green et al., 2005).

► The LSLS model has been widely criticised. The controversy mainly concerns the ways in which biodiversity is quantified and the fact that scale effects, ecological connectivity, human-nature balance, food security and land scarcity are not adequately considered in the model (Fischer et al., 2013). For example, even large areas of unused land are not sufficient to maintain viable wild species populations over the long term if species cannot migrate from neighbouring habitats (Halley et al., 2016). Consequently, an LSLS framework also needs to investigate how habitats can be connected and how diversity can be enhanced (Renwick and Schellhorn, 2016).

► The outline scenario for “zero net biodiversity loss in metropolitan France by 2030” developed during the workshop combines both *land sharing* and *land sparing* strategies. Under this scenario, zones of special importance for biodiversity conservation (biodiversity hotspots) are strongly protected. Outside these zones, a greening gradient is applied in accordance with the ecological and social characteristics of the areas concerned. Sustainable agriculture and forestry, and revegetation of urban environments is a priority everywhere, with requirement levels varying across different territories. The creation of an ecological network mitigates habitat destruction and fragmentation by removing the obstacles to species movements. It is based on tools such as the green and blue belt network and ecological infrastructure.



4.

ENERGY AND BIODIVERSITY

4.1 Interactions between Biodiversity and Energy SDGs and reference scenario

➤ The main interactions between the direct drivers of biodiversity loss and the targets of SDG 7 on energy uncover the synergies and tradeoffs between SDG 7 and SDG 15. At the scale of metropolitan France, the targets of increasing the share of renewable energy in the energy mix and improving energy efficiency have major implications for biodiversity, as illustrated in Table 4.1. These targets are central components of the négaWatt scenario which served as a reference for analysing the implications of the energy transition for biodiversity (négaWatt, 2017). NégaWatt is a normative scenario for a pathway in which France succeeds not only in totally decarbonising its energy system, but also in phasing out nuclear power by 2050 (Box 4.1).

4.2 Energy transition and biodiversity: synergies, trade-offs and uncertainties

➤ The targets of energy efficiency but also energy conservation, two of the three main pillars of the négaWatt scenario, reinforce the “zero net biodiversity loss” objective. The synergies are linked not only to the positive role of energy efficiency and conservation in mitigating climate change by reducing total final energy demand and hence the quantity of greenhouse gases emitted by the energy sector, but also to their role in limiting habitat degradation and pollution.

➤ The target of increasing the share of renewable energy in the energy mix, the third pillar of the négaWatt scenario, has mixed and sometimes uncertain effects on biodiversity. These effects are highly dependent on the context of renewable energy deployment, i.e. siting and installation size, and on the equipment production

Table 4.1 Examples of interactions between SDG 7 targets and mitigation of biodiversity loss

Direct drivers of biodiversity loss	Target 7.2. Share of renewable energy	Target 7.3. Energy efficiency
Habitat degradation	<ul style="list-style-type: none"> ➤ Solar farms may fragment habitats, hinder species movement and reduce food availability ➤ Bird and bat mortality through collisions with wind turbines ➤ A dam may block fish migration ➤ The transformation of a river into an artificial reservoir for hydropower generation modifies water levels and alters water temperature, chemical composition and dissolved oxygen content ➤ Energy production from biomass may lead directly or indirectly to changes in land use that cause habitat degradation (deforestation in particular) <p><i>Primarily negative interactions, highly dependent on the context of renewable energy deployment: site, installation size, processes for producing the equipment and materials used</i></p>	Positive interactions
Pollution	<ul style="list-style-type: none"> ➤ Wind turbine noise pollution ➤ Possible reduction in atmospheric pollution when renewable energy replaces fossil fuels <p><i>Negative or positive interactions dependent on the context of renewable energy deployment</i></p>	
Climate change	<ul style="list-style-type: none"> ➤ Possible reduction in greenhouse gas emissions when renewable energy replaces fossil fuels <p><i>Generally positive interactions dependent on the context of renewable energy deployment</i></p>	
Invasive alien species	Neutral	Neutral

processes, notably the materials used (Gasparatos et al., 2017). Generally speaking, the life cycle impacts of existing and emerging technologies and systems of renewable energy production on both greenhouse gas emissions and biodiversity are still poorly documented. The development of solar energy, as imagined in négaWatt, i.e. with no land-use competition, has few direct negative impacts on biodiversity. That said, the renewable energy development strategies deployed up to now in France, for solar power in particular, have favoured production by large-scale energy sector enterprises rather than end users, leading to the development of large solar farms with a greater potential impact on biodiversity through habitat degradation. Likewise, continued hydroelectric power generation at current levels may be an obstacle to waterway restoration. Last, wind power production has disruptive effects on biodiversity, notably for birds and bats, via sound pollution and habitat degradation (Barré, 2017). Avoiding sensitive sites such as migration corridors, limiting the size of turbine assembly areas or adopting offset measures through agroecological infrastructure development are examples of solutions deployed to mitigate the adverse

effects of wind turbines on biodiversity (Barre, 2017; Tosh et al., 2014).

► It is probably the scale of biomass increase in the négaWatt energy mix that is most problematic due to its potential impacts on habitats and the risks of overexploitation of resources. First-generation biofuels are abandoned in négaWatt. Energy from biomass is obtained mainly from byproducts of other sectors (wood-energy as a byproduct of the timber industry, hedge cuttings, methanisation of crop residues and plant cover, animal manure and organic waste). The aim is to avoid competition between land use for energy crops, food production, and ecosystem conservation. However, it is uncertain whether these byproducts are available in sufficient quantities to meet négaWatt's ambitions for biomass energy production. The envisaged methane production levels may result in inadequate return of organic matter to the soil. The growth of the wood-energy and timber industries under the négaWatt scenario raises the question of how these industries can be developed without affecting biodiversity.

Box 4.1 NégaWatt as a reference energy scenario

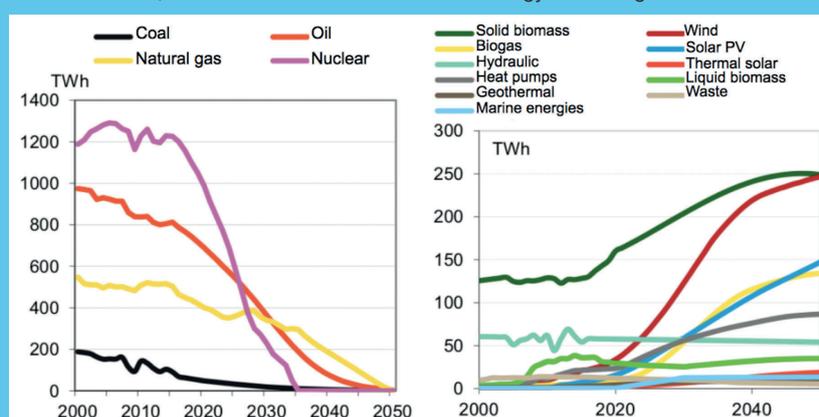
- The négaWatt scenario has been developed for France up to 2050. It is built on three pillars: energy conservation and efficiency, with a 25% reduction in final energy demand by 2030 and a 50% reduction by 2050, and an energy mix that is 100% renewable by 2050. Under this scenario, gas and electricity represent more than 70% of final energy in 2050, with the development of storage in the form of synthetic methane. Alongside agricultural and forest "carbon sinks" to offset residual emissions, these transformations enable France to become carbon neutral by 2050.
- Wind power generation is the leading electricity source in 2050. Onshore, and to a lesser extent, offshore wind power generation increase very rapidly, supplying 123 TWh in 2030 and 247 TWh in 2050,¹¹ with the gradual deployment of next-generation wind turbines with larger blades and higher efficiency in low winds;
- Solar power is a rapidly growing electricity source, with installations ranging from solar panels on the roofs of private

houses to large solar farms on brownfield sites or wastelands unfit for agricultural use;

- Hydropower generation is stable, the decline in water resources due to climate change being offset by the modernisation of existing structures with no impact on biodiversity;
- Biomass (solid, liquid, biogas) becomes the leading energy source with no creation of land-use competition. Wood energy is produced mainly from wood derived from other uses (including timber). Biogas is produced from crop residues, manure, biowaste and plant cover (methanisation);
- The last nuclear reactor is shut down in 2035 and oil, fossil gas and coal have disappeared from the French energy landscape by 2050.

The scenario "only makes significant use of technologies that are already sufficiently mature to provide guarantees of timely availability, in sufficient quantity, at an affordable cost and with acceptable impacts".

Fossil fuels, fissile resources and renewable energy in the négaWatt scenario



Source: adapted from négaWatt, 2017

¹¹ This increase corresponds to a continuation of current trends: between 2015 and 2019, installed capacity in France rose by 54%, reaching 16019 MW in September 2019 (Observ'ER, 2019) and wind power generation rose by 25% between 2016 and 2018 (Observ'ER, 2019 ; 2017).

5.

AGRICULTURE & FOOD AND BIODIVERSITY

5.1 Interactions between Biodiversity and Agriculture & Food SDGs and reference scenarios

► At the scale of metropolitan France, the targets of providing access to sufficient, safe and nutritious food, raising incomes for food producers, developing sustainable and resilient agriculture, and maintaining genetic diversity may have major implications for biodiversity, as shown in Table 5.1. These targets are central to the various options of transition towards more sustainable farming systems, such as sustainable or ecological intensification (Pretty, 1997) which seeks to make more efficient use of resources and input¹², or agroecology (Altieri, 1989) which focuses on preserving biodiversity and “maximising the use of ecological processes in the functioning of agroecosystems” (Poux and Aubert, 2018).

► While ecological intensification seeks to reduce inputs, including land (Balmford et al., 2005), agroecology corresponds more closely to our outline scenario for biodiversity which gives priority to biodiversity-friendly agriculture, with the exception of conservation priority areas which are strongly protected and have little or no farming activities. Two scenarios of agroecological transition by 2050, Afterres2050 and Ten Years for Agroecology (TYFA) served as a reference for analysing the implications of this transition for biodiversity (Solagro, 2016; Poux and Aubert, 2018) (Boxes 5.1 and 5.2). These two scenarios address the same key challenges. In 2050, agriculture at the scale of Europe in TYFA, or of France in Afterres2050, contributes to conservation of biodiversity and water resources, is more resilient to climate change and contributes to its mitigation. Under both scenarios, the agroecological transition produces a more pronounced decrease in yields, production and exports of agricultural products than in trend-based scenarios.¹³ However, sufficient food is produced for the European or French population and, in Afterres2050, agricultural employment is maintained while the trend-based scenarios forecast a decreasing number of farms and farming jobs.¹⁴ These results are largely based on a strong assumption of changes in modes of consumption and dietary habits and highlight the synergies between environmentally-friendly agriculture and eating habits more in line with nutritional recommendations.



¹² Initially centred on the capacity of agriculture to produce more with fewer inputs (Lang and Barling, 2012 ; Mueller et al., 2012), the concept of ecological intensification gradually expanded into other dimensions such as the health and nutritional quality of foods (Smith, 2013), preserving the long-term capacity of land to produce food and other services (Garnett et al., 2013), social and ethical sustainability (Buckwell, 2014).

¹³ More specifically, in TYFA and Afterres2050, production of cereals, fodder and animal products decreases while that of fruit, vegetables and pulses increases.

¹⁴ The 2018 version of the TYFA scenario does not cover employment questions.

Table 5.1 Examples of interactions between SDG 2 targets and mitigation of biodiversity loss

Direct drivers of biodiversity loss	Target 2.1a Sufficient food*	Target 2.1b Safe and nutritious food*	Target 2.3. Food producers' incomes	Target 2.5. Genetic diversity
Habitat degradation	<p>➤ If the sufficient food target leads to agricultural intensification or expansion it accelerates habitat degradation, pollution and greenhouse gas emissions</p> <p>Negative interactions</p>	<p>➤ The growth of organic farming is conducive to healthier food and reduces habitat degradation</p> <p>➤ Greater dietary diversity fosters diversity of plant and livestock species, varieties and breeds</p> <p>Positive interactions</p>	<p>➤ The adoption of farming practices that limit habitat degradation and pollution and that help to mitigate climate change affects production costs (either upward or downward) and may lower yields</p> <p>➤ Farmers setting up in small-scale farming in France, mainly specialise in organic farming as the margins are higher</p>	<p>➤ Regulating services provided by biodiversity (conservation of habitats, air and water quality, climate)</p> <p>Positive interactions</p>
Pollution		<p>➤ The growth of organic farming is conducive to healthier food, reduced pollution and lower greenhouse gas emissions</p> <p>Positive interactions</p>	<p>Negative or positive context-dependent interactions</p>	
Climate change				
Invasive alien species	<p>➤ Invasive species affect agricultural production via their effects on nutrient recycling, soil protection and regeneration, crop pollination and seed dispersal</p> <p>Positive interactions</p>	<p>➤ Some invasive species may incur food safety risks</p> <p>Positive interactions</p>	<p>➤ The eradication of invasive alien species incurs costs for farmers</p> <p>Positive interactions</p>	<p>➤ Invasive alien species have negative impacts on the diversity of indigenous species</p> <p>Positive interactions</p>

* Given that the target of producing sufficient, healthy and nutritious food does not have the same implications for biodiversity, Target 2.1 of SDG 2 was divided into two parts.

5.2 Agroecological transition and biodiversity: synergies, trade-offs and uncertainties

➤ Under TYFA and Afterres2050 scenarios, the change in diet acts in the same way as the principle of energy conservation in the energy transition by lifting pressure on natural resources through waste reduction, increased demand for organic foods and limited consumption of animal-based products, which are partly replaced by protein-rich plant-based foods, fruits and vegetables, thereby expanding the diversity of cultivated species and varieties.¹⁵ The spread of agroecological infrastructure¹⁶ and the development of agroforestry which, in Afterres2050, represents 10% of cultivated land in 2050, contributes to habitat restoration. TYFA projects an end to chemical inputs by 2050 while Afterres2050 aims for a four-fold reduction of pesticide use and a two-fold reduction in synthetic fertilizer use. The decrease in agricultural pollution due to the development of organic farming fosters greater biodiversity and enhances food safety.^{17,18} Changes in livestock rearing are characterised by a decrease in production, a revival of dual-purpose cattle breeds (milk and meat) and rustic breeds, and mixed crop-livestock farming systems. This makes it possible to include temporary pastures of leguminous plants in crop rotations and to use organic nitrogen more effectively, but also to reduce or even eliminate dependence on chemical fertilizers and soya imports.

➤ While the two scenarios are very similar, they differ in their spatial scale, but also in the relative importance of the objectives considered. Afterres2050 places more emphasis on agriculture's contribution to climate change mitigation while TYFA focuses on biodiversity conservation. Comparison of the two scenarios reveals the potential trade-offs between the two objectives via their respective assumptions about changes in pastureland area and on-farm energy production.

➤ Permanent pastures, natural pastures in particular (permanent pastures with little or no chemical input) are of key importance for both biodiversity and the climate. They represented 32.5% of the agricultural land area in metropolitan France in 2018. Some 77,000 hectares of permanent pastures were lost annually between 1960 and 2000, and 44,000 hectares annually between 2000 and 2018 (Agreste, 2019). Under the Afterres2050 scenario, 1.1 million hectares of permanent pasture are lost between 2010 and 2050, i.e. 27,500 hectares per year. While permanent pasture loss is more limited than in the trend-based scenario, it is not compatible with the “zero net biodiversity loss” objective. However, the stabilisation of permanent pasture areas (at the European level) under the TYFA scenario, while favourable to biodiversity, is associated with a much smaller drop in beef production compared to the Afterres2050 scenario. Under TYFA, the production and consumption of monogastric animal products falls sharply, while that of red meat remains practically unchanged. As a consequence, agricultural methane emissions fall less sharply in TYFA than in Afterres2050, and are not offset by the additional carbon storage capacity of the preserved pasture land areas.^{19,20} As a consequence, while agricultural greenhouse gas emissions in France are halved between 2010 and 2050 under Afterres2050, they are only divided by 1.5 in TYFA at the European level.

➤ Agriculture does not contribute to renewable energy production in TYFA, whereas on-farm biogas production develops in Afterres2050. The growth of biogas raises questions about its compatibility with the biodiversity objective. As mentioned in the previous section (Afterres2050 is the agricultural dimension of négaWatt), the envisaged biogas production levels may result in inadequate return of organic matter to the soil. Moreover, efforts to improve profitability at farm level may encourage operators to methanise not only crop residues and manure, but also cereals and intermediate crops.

¹⁵ The decrease in consumption of animal-based products in Afterres2050 is aligned with the dietary profile of “organic consumers” in the Nutrinet-Santé study cohort (Kesse-Guyot et al., 2020 ; Baudry et al., 2019).

¹⁶ Agroecological infrastructures are defined as “semi-natural habitats that do not receive chemical fertilizers or pesticides and that are managed extensively: certain permanent pastures, mountain pastures, moors, hedges, isolated trees, forest edges, grass verges, field edges, fallow land, terraces and walls, ponds and ditches, etc.” (Solagro, 2016). In metropolitan France, according to the Teruti-Terra surveys, areas covered by hedges and rows of trees decreased by 8,000 ha. per year between 2006 and 2014, and 21,000 ha. of copses were lost annually over the same period (Agreste, 2019).

¹⁷ Generally speaking, organic agriculture, notably horticulture and livestock rearing, is more affected by pollution of all origins than greenhouse farming (including hydroponic) and intensive livestock production. The healthiness of organic food is thus dependent on a reduction of all types of pollution.

¹⁸ As pointed out by the authors of the TYFA scenario, the prevalence of mycotoxins presenting a health risk for consumers does not appear to differ significantly between organic and non-organic foods. The absence of chemical fungicides in organic agriculture is offset by cultivation practices that limit the risk of mycotoxin contamination (AFSSA, 2003).

¹⁹ The trade-off between biodiversity and climate may be accompanied by a trade-off between biodiversity and healthiness, given the adverse health effects of red meat consumption. However, the TYFA assumptions about European red meat consumption comply with nutritional guidelines. In addition, there is still controversy over the health effects of red meat consumption, which mainly concern processed red meat. Without any assumptions on the processing of food consumed by Europeans, it cannot be presumed that the diet envisaged in the TYFA scenario carries a higher health risk. Last, the authors of the TYFA scenario point out that “the omega 3 content of ruminant milk and meat is more than doubled if the animals are fed with grass rather than maize silage”. This is an important benefit “in a context where European consumption [of products rich in omega 3] is less than half the recommended amount, on average” (Poux and Aubert, 2018).

²⁰ On a global level, animal-based products are responsible for more greenhouse gas emissions than any other food source (14.5% of anthropic emissions). Cattle (meat, milk) produce methane in the digestion process and alone account for two-thirds of livestock greenhouse gas emissions (IPCC, 2014).



Box 5.1 Afterres2050: a scenario of agricultural and dietary transition for France by 2050

➤ The Afterres2050 scenario was developed by Solagro between 2011 and 2016; it is the agricultural and silvicultural component of the négaWatt scenario and relies on the generalisation of the best agricultural technologies and practices available today.

A profound dietary transformation

- Reduction of food overconsumption (-33%), losses and wastage (-50%), and of animal product consumption (-40%);
- Increased consumption of plant proteins, whole grains, fruits, vegetables, pulses and nuts.

Generalised agroecology for more environmentally-friendly production

- Half of arable land for organic farming, the other half for integrated farming or conservation agriculture;
- Generalised use of permanent plant cover and no-till or minimum tillage techniques;
- Rapid growth of legume crops, intercrops and associated crops;
- Generalisation of agroecological infrastructure (doubling of hedge length);
- Rapid growth in agroforestry;
- Plant production equivalent to current levels despite a sharp drop in yields (-36%);
- Diversification of production, increase in horticulture and tree crops;
- Halving of greenhouse gas, of energy consumption, of summer irrigation, of mineral nitrogen consumption, 3-fold reduction in ammonia emissions, 4-fold reduction in crop protection products.

A new approach to livestock breeding

- Extensification of livestock rearing, with mixed livestock and crop farming;
- Sharp decrease in meat production, beef in particular, but doubling of sheep and goat flocks;
- Generalisation of quality labels;
- Cessation of soya meal imports, more limited use of concentrates and increase in cattle grazing.

Land use

- 0.5 Mha increase in forested land area;
- Slower loss of agricultural land area (-1.4 Mha between 2010 and 2050, of which -1.1 Mha of permanent pastures).

More balanced trade with the rest of the world

- 16% decrease in exported volumes;
- 60% increase in food grain exports to the Mediterranean and Middle East regions;
- Halving of feed grain exports to Europe;
- Cessation of soya imports and elimination of the trade deficit in the forest and wood products sector.

Development of biomass usage

- Increased wood harvesting, combined production of timber (construction) and wood-energy;
- Rapid growth in agricultural biogas production.

Source: adapted from Solagro, 2016

Box 5.2 TYFA, an agroecological Europe in 2050

➤ The TYFA (Ten Years for Agroecology) scenario was developed by IDDRI and ASCA between 2016 and 2018 for an agroecological Europe in 2050. Afterres2050 and TYFA are based on similar visions and are both normative scenarios constructed on the basis of physical models. However, TYFA differs from Afterres2050 in the following respects:

- European scale;
- Generalisation of organic farming, with more pronounced decreases in production and yields;
- Permanent pastures, beef production and consumption maintained at current levels; decrease in pork and poultry production;
- 10% reduction in losses and wastage;
- No use of agricultural biomass for energy production.

**The main assumptions of the TYFA scenario**

1. Fertility management at the territorial level that depends on :

- The suspension of soybean/plant protein imports
- The reintroduction of legumes into crop rotations
- The re-territorialisation of livestock systems in cropland areas

2. The phase-out of synthetic pesticides and the extensification of crop production - all year soil cover: organic agriculture as a reference

3. The redeployment of natural grasslands across the European territory and the development of agro-ecological infrastructures to cover 10% of cropland

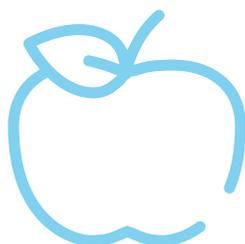
4. The extensification of livestock production (ruminants and granivores) and the limitation of feed/ food competition, resulting in a significant reduction in granivore numbers and a moderate reduction in herbivore numbers

5. The adoption of healthier, more balanced diets according to nutritional recommendations
 ➤ A reduction in the consumption of animal products and an increase in plant proteins

➤ An increase in fruit and vegetables

6. Priority to human food, then animal feed, then non-food uses

Sources : adapted from Poux and Aubert, 2018



URBANISATION AND BIODIVERSITY

6.1 Interactions between Biodiversity and Urbanisation SDGs and reference scenario

- ▶ The main interactions between the direct drivers of biodiversity loss and the targets of SDG 11 (Urbanisation) reveal the synergies and trade-offs between SDG 11 and SDG 15. Among the targets of SDG 11, access to sustainable transport systems; reducing the environmental impact of cities; access to green spaces; and support for positive links between urban, peri-urban and rural areas have major implications for biodiversity in metropolitan France (Table 6.1).
- ▶ The “Ville contenue” (compact city) scenario developed in a study by ADEME and MEDDE (Box 6.1) served as a reference to analyse the implications of the urban transition for biodiversity (Theys and Vidalenc, 2013). “Ville contenue” is one of the five scenarios developed in this study, corresponding to five strategies for attaining the same three objectives in 2050: (1) a three- to four-fold reduction in greenhouse gas emissions; (2) oil independence (and reduced dependence on nuclear power and other fossil fuels); and (3) adaptation to climate change. Among the five scenarios, “Ville contenue”, which combines these objectives with that of preserving biodiversity, is the one most closely aligned with the outline scenario for biodiversity.

Table 6.1 Examples of interactions between SDG 11 targets and mitigation of biodiversity loss

Direct drivers of biodiversity loss	Target 11.2 Safe, accessible and sustainable transport	Target 11.6. Environmental impact of cities	Target 11.7. Universal access to green spaces	Target 11.a National and regional development planning
Habitat degradation	<ul style="list-style-type: none"> ➤ New railway lines may fragment ecosystems ➤ The development of “greenways” combining cycle paths and ecological corridors may contribute to habitat restoration <p>Positive and negative context-dependent interactions</p>	<ul style="list-style-type: none"> ➤ Limiting urban sprawl helps to mitigate ecosystem degradation ➤ Increased urban density may lead to less nature in the city <p>Positive and negative context-dependent interactions</p>	<ul style="list-style-type: none"> ➤ Creation of new green spaces and ecological rehabilitation of existing ones contribute to habitat restoration <p>Positive interactions</p>	<ul style="list-style-type: none"> ➤ The development of leisure activities in peri-urban areas may encourage land take and increase associated levels of pollution and disturbance ➤ Stakeholder involvement in urban agriculture projects can limit land take and urban sprawl <p>Positive and negative context-dependent interactions</p>
Pollution	<ul style="list-style-type: none"> ➤ Promotion of active mobility and public transport reduces air pollution and CO₂ emissions <p>Positive interactions</p>	<ul style="list-style-type: none"> ➤ Less waste generation means fewer pollution sources <p>Positive interactions</p>	<ul style="list-style-type: none"> ➤ Urban wetlands and forests help to filter the air and reduce concentrations of liquid waste, small particulates, noise, heavy metals and ozone <p>Positive interactions</p>	
Climate change		<ul style="list-style-type: none"> ➤ Promoting the energy efficiency of buildings limits CO₂ emissions <p>Positive interactions</p>	<ul style="list-style-type: none"> ➤ Planting trees in urban areas reduces the “heat island” effect and stores CO₂ <p>Positive interactions</p>	<ul style="list-style-type: none"> ➤ Promoting local food systems can limit CO₂ emissions <p>Positive and negative regional planning-dependent interactions</p>
Invasive alien species	<p>Neutral at local level</p>	<ul style="list-style-type: none"> ➤ Urban green spaces tend to be planted with exotic species appreciated for their beauty or ease of cultivation. They nonetheless provide a suitable habitat for diverse native non-invasive species <p>Positive and negative interactions dependent on the types of green space</p>		<p>Neutral</p>

6.2 Urban transition and biodiversity: synergies, trade-offs and uncertainties

➤ As is the case for the energy and agroecological transitions, cities must first seek to reduce their environmental impact through resource conservation and efficiency. In this respect, two dimensions should be considered: first, the direct impacts of urban expansion involving the conversion of farmland, forests and natural areas (grassland, wetlands, etc.); second, the indirect impacts associated with urban consumption and waste production.

➤ The first dimension, linked to direct urban impacts, raises questions about the very structure of the urban environment. In this respect, the “Ville contenue” scenario imagines a compact city that limits habitat degradation and consumes less space, much like the *land sparing* strategy. Increasing urban density offers a means to address the problem of urban sprawl characterized by low-density housing, segregated land use, and strong dependence on private cars (Johnson, 2001). As in the rest of Europe, urbanisation in France has followed a pattern of urban expansion and peri-urban growth resulting from the migration of populations and businesses towards municipalities close to cities, but not adjoining them. France has been particularly affected by peri-urbanisation and low-density housing developments, single-family houses especially (Desrousseaux et al., 2020).

➤ As land take increases with urban sprawl, the functions of soil are modified (control of the water cycle; pollutant retention and degradation; carbon storage; plant biomass production; medium of biodiversity) (Desrousseaux et al., 2020). Urban sprawl affects landscapes and living environments, both directly by destroying or fragmenting them, and indirectly via the resulting human activities that modify the physical environment, such as air temperature and quality, or the water cycle (ibid). Urban sprawl has two key impacts on biodiversity: loss and fragmentation of natural habitats, and a mean decline in biodiversity and in abundance of local species (McDonald et al., 2020; Desrousseaux et al., 2020; Concepción et al., 2015).

➤ Compact cities comprising densely urbanised areas connected by public transport systems facilitate access to services and jobs close to workers’ homes (OECD, 2012). However, the impact of urban densification on biodiversity has rarely been documented or quantified (Haaland and Konijnendijk van den Bosch, 2015). While high-density urban development may have a positive impact at agglomeration level by preserving peripheral land, it leaves little space for nature (Haaland and Konijnendijk van den Bosch, 2015; Sushinsky et al., 2013). Moreover, densification does not necessarily reduce CO₂ emissions (Gray et al., 2010), and while it reduces dependency on

cars and shortens commuting distances, thus reducing air pollution, it increases individual exposure to high pollution levels (Desrousseaux et al., 2020). It may also generate traffic congestion (Melia et al., 2011), adverse effects on quality of life, when dense urban living provokes anxiety, for example (Mouratidis, 2019), and more frequent heat island episodes, at night especially (Lemonsu et al., 2015). It is therefore important to avoid a simplistic distinction between compact city and sprawling city, and to imagine more complex urban forms designed to mitigate all the drivers of biodiversity loss and to take account of other SDGs such as health and well-being or the reduction of inequalities.

➤ The second dimension, linked to indirect urban impacts, concerns urban modes of production and consumption and urban lifestyles, and their impact on ecosystems at both local and broader levels. The term “imported sustainability” is used in reference to cities that export the cost of their sustainability to neighbouring or more distant territories (Mancebo, 2011), for example through water supply systems that degrade adjacent aquatic ecosystems (McDonald et al., 2014; Fitzhugh and Richter, 2004), or through deforestation for agriculture or timber production (Puppim de Oliveira et al., 2011).

➤ Urban and extra-urban transport systems affect biodiversity both by emitting greenhouse gases and by disrupting ecological connectivity (EEA, 2016). Under the “Ville contenue” scenario, private cars are increasingly replaced by public transport, favouring compactness and limiting greenhouse gas emissions. While helping to mitigate climate change, the development of linear transport infrastructures such as railways is liable to disrupt ecological continuity and destroy habitats (Villemey et al., 2018; Karlson and Mörtberg, 2015; Antrop, 2004). Mitigation measures such as ecoducts are therefore needed (Mimet et al., 2016 ; Glista et al., 2009).²¹ Last, in the “Ville contenue” scenario, the promotion of low-impact mobility such as cycling and walking via the development of multipurpose greenways provides a means to restore ecological corridors and habitats (Carlier and Moran, 2019).

➤ To promote universal access to green spaces, the “Ville contenue” scenario focuses on creating green roofs and walls, and preserving peri-urban natural areas, agricultural land and existing urban parks. Urban parks provide wide-ranging ecosystem services, including control of climate (notably heat island mitigation), regulation of air quality and natural hazards, as well as cultural, leisure and socialisation services (Gómez-Baggethun and Barton, 2013). They are also key to preserving urban biodiversity through the abundance of species they may potentially contain (Nielsen et al., 2013). Beyond private gardens and public parks, urban agriculture – often organised on

²¹ Ecoducts are wildlife bridges or tunnels enabling animals and plants to cross anthropic obstacles such as railway lines or motorways.

a collaborative basis – also provides a means to restore urban biodiversity while providing a fresh food source for urban populations (Mancebo, 2018; Lagneau et al., 2014). The densification process may damage natural habitats, notably through urban infill,²² with high-density construction projects encroaching upon urban natural spaces (Pauleit et al., 2005).

➤ Last, no city can be viewed in isolation from its surrounding rural areas. While rural areas provide environmental services to cities, such as agricultural production and climate control, they receive negative externalities from the city in return, in the form of water and air pollution. The “Ville contenue” scenario proposes several lines of approach for the future of rural areas in a context of almost complete reorganisation of French cities into dense urban hubs: (i) increased protection against land take for certain sparsely populated zones, with development centred on farming and forestry activities or management of protected areas; (ii) areas providing recreational and tourist infrastructure for the

urban majority, accessible by public transport; and (iii) rural residential areas inhabited by both retirees and young workers in a local and/or teleworking economy. Urban-rural solidarity can also be reinforced by developing economic and social links between city and countryside, via regional food supply chains or new forms of local ecotourism, for example (Jaeger, 2018).

Box 6.1 “Ville contenue”: a scenario for urban transition up to 2050

- The “Ville contenue” scenario is one of the five scenarios for the period up to 2050 included in the study entitled *Repenser les villes dans la société Post-carbone* (Rethinking the city in a post-carbon society) published in 2013 by ADEME and the MEDDE Scenario Development Mission (Ministry of the Environment CGDD-DDD).
- Agglomerations are more compact and more balanced, combining a functional mix (employment and housing) and social diversity;
- They are structured by efficient public transport networks, with limited access to city centres for private motor vehicles;
- Urban sprawl is controlled, notably to reduce energy consumption, by means of coordinated policies for transport management, housing construction, urban renovation, and land management by the local authorities;
- Nature is present in the city centre and beyond: green spaces (urban parks, green infrastructure, etc.) are developed to their full potential, and farmland and natural areas between built-up zones are preserved and interconnected via green infrastructure or natural corridors that extend into the city centre;
- Adaptation to climate change is an integral component of urban planning. For example, building on flood-prone areas is limited, floodplains are extended and natural areas and forests are developed;
- Measures are taken to redensify inner suburbs;
- Peri-urban areas are reorganised with a view to concentrating urbanisation around a small number of hubs accessible by public transport;
- Municipalities located furthest from the urban hubs are progressively «deurbanised».

Source: adapted from Theys and Vidalenc, 2013



²² Urban infill refers to the construction of new buildings on “underused” urban land, such as brownfield sites or private gardens.

IMPLICATIONS OF THE ENERGY, AGROECOLOGICAL AND URBAN TRANSITIONS FOR FRESHWATER, CLIMATE, OCEANS AND INEQUALITIES

► The transitions analysed for SDG 6 - Freshwater, SDG 10 - Inequalities, SDG 13 - Climate, and SDG 14 - Oceans have multiple implications, presented in Tables 7.1 and 7.2. They give rise to synergies, shown in green, or contradictions, shown in red. The questions, shown in blue, reflect uncertainties about the implications of the energy, agroecological and urban transitions for SDGs 6, 10, 13 and 14, for which further research is needed.

► While the energy, agroecological and urban transitions mainly generate co-benefits for the freshwater, climate, oceans and inequalities SDGs, these co-benefits are dependent on the spatial and time scales considered. The positive impacts of these transitions in terms of mitigating climate change and ocean acidification will not be perceptible by 2030. Likewise, if these transitions are limited exclusively to France, they will have little impact on these variables. The negative effects of the energy, agroecological and urban transitions are very limited, and can be mitigated by taking them into account when defining the assumptions of our biodiversity scenario. For example, the negative effects of offshore or onshore wind farms built in close proximity to rural populations can be avoided, mitigated and sometimes offset in our biodiversity scenario by conditioning their deployment upon the findings of studies conducted throughout their lifecycle to assess their impact on terrestrial and marine biodiversity, greenhouse gas emissions and the quality of life of surrounding populations. Likewise, to limit the risk of increased water stress due to the development of green spaces, horticulture and farming in urban areas, our scenario must assume that species and varieties, as well as production and maintenance methods, are chosen in accordance with local conditions and climate change.

► The uncertainties about the implications of the envisaged transitions for SDGs 6, 10, 13 and 14 point up challenges that must be taken into account in our biodiversity scenario. For example, the impacts of the urban transition on the oceans will depend substantially on the nature of this transition in coastal areas. Moreover, terrestrial coastal zones are particularly biodiverse. Uncertainties about the urban and energy transition linked to potential demand for

ores and marine energy lay bare challenges which extend beyond the oceans. These uncertainties concern both the consequences for biodiversity of extracting the raw materials needed for the energy transition, and the impacts of the ever-growing digital economy on energy demand, and hence on biodiversity. Last, the implications of the urban transition for rural population access to transport infrastructures and to other services highlight more generally that our biodiversity scenario calls for a more in-depth analysis with regard to territorial planning and the future of rural areas than that outlined in the section on the urban transition. The questions raised by the implications of the energy, agroecological and urban transitions for inequalities provide a starting point for examining pathways. They reveal the extent to which inequalities are powerful obstacles to the transitions envisaged. If energy-efficient homes, sustainable modes of transport and healthy food are not affordable for most people, the envisaged transitions will concern only a small fraction of the population and the objective of “zero net biodiversity loss” will be unattainable.

Table 7.1 Implications of the energy, agroecological and urban transitions for SDGs 6 and 13

SDG	Targets	Energy transition	Agroecological transition	Urban transition
Fresh water	Water pollution	<ul style="list-style-type: none"> ➤ The decline of nuclear power generation reduces heat pollution 	<ul style="list-style-type: none"> ➤ Reduced pesticide use and the development of agroecological infrastructure and agro-forestry improve water quality 	<ul style="list-style-type: none"> ➤ Limiting urban sprawl and developing urban green spaces improve water quality (wetland creation and restoration) ➤ The development of urban agriculture with no chemical inputs improves water quality
	Water-related ecosystems	<ul style="list-style-type: none"> ➤ The decline of nuclear power generation reduces ecosystem disturbance (smaller volumes of cooling water) ➤ The development of nature-based solutions for hydro power generation favours ecosystem restoration 	<ul style="list-style-type: none"> ➤ Reduced pesticide use and the development of agroecological infrastructure (cessation of land drainage and expansion of wetland areas) improve the state of aquatic ecosystems 	<ul style="list-style-type: none"> ➤ Control of urban sprawl limits wetland disturbance ➤ The preservation of natural and agricultural land between and within densely urbanised zones (green spaces, green infrastructure or natural corridors) includes waterways and their ecosystems
	Abstraction		<ul style="list-style-type: none"> ➤ Optimisation of carbon storage in soil reduces irrigation needs by enhancing soil water retention ➤ The adaptation of crops, plant varieties and animal breeds to local climates reduces pressure on water 	<ul style="list-style-type: none"> ➤ Control of urban sprawl improves water supply (fewer leaks) ➤ Wastewater recovery and reuse eases quantitative pressure ➤ More urban green spaces may increase the volumes of water abstracted for their upkeep
Climat	Adaptation	<ul style="list-style-type: none"> ➤ The decrease in nuclear power generation reduces the risk of power cuts due to low waterway levels in summer 		<ul style="list-style-type: none"> ➤ The development of irrigated urban agriculture would increase water stress
	Mitigation	<ul style="list-style-type: none"> ➤ Lower fossil fuel consumption reduces greenhouse gas emissions 	<ul style="list-style-type: none"> ➤ Less chemical fertilizer production and better fertilisation management reduce greenhouse gas emissions ➤ Less waste and overconsumption reduce greenhouse gas emissions ➤ Less red meat consumption reduces greenhouse gas emissions ➤ The development of agroecological infrastructure, agroforestry, intermediate crops, etc. contributes to carbon storage 	<ul style="list-style-type: none"> ➤ The development of public transport networks reduces greenhouse gas emissions ➤ Limiting land take contributes to carbon storage ➤ Urban greening contributes to carbon storage

Table 7.2 Implications of the energy, agroecological and urban transitions for SDGs 10 and 14

SDG	Targets	Energy transition	Agroecological transition	Urban transition
Ocean	Marine pollution	<ul style="list-style-type: none"> > The decline of fossil fuels reduces marine pollution caused by plastic waste and maritime transport > Offshore wind farms may increase marine pollution 	<ul style="list-style-type: none"> > Decreased use of chemical inputs and changes in livestock rearing practices have significant impacts on estuaries, coastal areas and oceans (less eutrophication thanks to reduced nutrient loads, and restoration of a balanced food web) 	<ul style="list-style-type: none"> > Urban greening and control of urban sprawl reduce water runoff and pollution of coastal areas and oceans
	Degradation of marine and coastal ecosystems	<ul style="list-style-type: none"> > The decline of fossil fuels is associated with less offshore extraction > Offshore wind farms may disturb migratory species > What are the offshore mineral needs of renewable energy development? 		<ul style="list-style-type: none"> > Containment of urban sprawl may reduce demand for marine aggregates
	Acidification	<ul style="list-style-type: none"> > The decline of fossil fuels helps to mitigate acidification over the long term 	<ul style="list-style-type: none"> > Reduced chemical fertilizer production helps to mitigate acidification over the long term 	<ul style="list-style-type: none"> > Public transport development and reduced land take help to mitigate acidification over the long term
	Fishing	<ul style="list-style-type: none"> > The decline of fossil fuels may reduce fishing capacity > The development of marine energies restricts fishing around energy infrastructure 	<ul style="list-style-type: none"> > The development of local food systems and lower consumption of fish products favour small-scale fishing and smaller catches 	
Inequalities	Inequalities of income and access	<ul style="list-style-type: none"> > By consuming energy produced in adjacent territories, urban zones provide economic opportunities in rural areas 	<ul style="list-style-type: none"> > Renewable power generation in rural areas may generate environmental nuisance for surrounding populations > How can sustainable modes of energy consumption be made accessible to all? 	<ul style="list-style-type: none"> > The development of local food systems and food quality labels provides a potential means to raise farmers' incomes and reduce inequalities between small- and large-scale farmers > How can sustainable modes of food consumption be made accessible to all?
	Social, economic and political integration		<ul style="list-style-type: none"> > Local food systems strengthen social relationships 	<ul style="list-style-type: none"> > Density, well-developed public transport and functional mixing in urban hubs facilitate universal access to socialisation activities and services > Community gardens and urban agriculture (in a context of reduced pollution) provide access to healthier food for urban populations > More urban green spaces provide broader access to the benefits of nature > How can sustainable living arrangements and transport be made accessible to all? > What are the implications of the urban transition for rural access to transport infrastructure, social and cultural services, etc.?
			<ul style="list-style-type: none"> > Community gardens foster social relationships among urban dwellers > The greater functional mix of urban hubs reduces spatial segregation 	

8.

BIODIVERSITY SCENARIO:

Main assumptions and uncertainties

8.1 The Energy component of the scenario

► Our biodiversity scenario uses or adapts certain assumptions of the négaWatt scenario, but leaves aside those whose implications for biodiversity are too uncertain. The négaWatt assumptions of reductions in final energy consumption (–25%) and primary energy production (–40%) between 2010 and 2030, made possible by energy conservation and efficiency measures, are used as they stand in our scenario. Likewise for the assumptions on coal, fossil gas and oil-based energy production. These energy sources are not totally absent from the energy mix in 2030, but our scenario is entirely consistent with a pathway towards total decarbonisation by 2050.

► The négaWatt assumptions for the non-biomass renewable energy mix are used under certain conditions in our scenario. The deployment of these energies, i.e. siting and installation size, and the processes used to build the necessary infrastructure, notably the materials used, are conditional upon the findings of studies conducted throughout their lifecycle to assess their impact on terrestrial and marine biodiversity, greenhouse gas emissions and the quality of life of surrounding populations. Last, our scenario makes no conclusions about the scale of biomass energy production as the implications for biodiversity of the négaWatt assumptions on wood energy and methanisation are too uncertain. Although our scenario proposes a pathway towards rapid decarbonisation, it makes no assumptions about the scale of biomass energy production, and so is necessarily uncertain as to the speed of nuclear power phase-out.

8.2 The Agriculture & Food component of the scenario

► Our biodiversity scenario forms part of the agroecological transition as imagined in Afterres2050 for France or TYFA for Europe. The decrease in chemical inputs projected for 2050 in Afterres2050 (halving of mineral nitrogen consumption, 4-fold reduction in crop protection products compared to 2010) is envisaged for 2030 in our scenario, as a stage towards their total elimination in 2050. As the decrease in chemical inputs is closely linked to the other changes in modes of food production and consumption, most of the other assumptions made in Afterres2050 for 2050 are included in our scenario for 2030. Losses and waste are reduced by 50% and excess consumption with respect to nutritional

guidelines is reduced by one-third with respect to 2010. The decrease in consumption of animal-based products (–40%) is offset by an increase in consumption of fruits and vegetables and protein-rich plant-based foods. Local food systems become more widespread and demand for high-quality products increases. Agroecological practices are more widely implemented and are accompanied by the growth of agroecological infrastructures and agro-forestry and a 30% decrease in water consumption for irrigation. Livestock systems are transformed by extensification and a return to the system of mixed crop and livestock farming.

► By 2030, 50% of land is farmed organically. The decrease in yields is less pronounced in our scenario than in Afterres2050, however,²³ firstly because climate change will have a smaller impact on yields in 2030 than in 2050,²⁴ and secondly, because the Afterres2050 yield assumptions, based on a generalisation of practices and techniques that already exist, are prudent. Organic crop yields will increase at a faster rate under our scenario. “Rigorous” agroecological practices (no inputs) are developed more rapidly in zones of special importance for biodiversity conservation. The pace of the agroecological transition is tailored to the local context via public support policies, in accordance with pedoclimatic, ecological and socioeconomic conditions.

► Biogas production increases under our biodiversity scenario but, as indicated for the energy transition, no production levels are given. They must be compatible with sufficient return of organic matter to the soil and should avoid creating land-use competition between food and energy crops. Lastly, our scenario does not incorporate the Afterres2050 assumption of a decrease in permanent pastures due to land take which would represent a net biodiversity loss. However, maintaining pasture areas and cattle numbers, as suggested in TYFA (at the European level), has implications for greenhouse gas emissions, and hence for climate change and biodiversity. This trade-off raises questions about the possibility of maintaining the surface area of permanent pastures while reducing cattle numbers, or offsetting permanent pasture loss by expanding other types of biodiverse agricultural land.

²³ Under the Afterres 2050 assumptions, yields fall by 27% between 2010 and 2050, compared with 7% over the same period due to climate change under the trend scenario.

²⁴ Afterres2050 adopts the RCP 6.0 scenario of the 5th IPCC report, which gives for France: +1.6°C for 2020-2050 and +3°C for 2070-2100 (for a world average of +2.2°C).

8.3 The Urbanisation component of the scenario

➤ The urban transition in our biodiversity scenario is based on the “Ville contenue” assumptions of slowing urban sprawl. The slowdown occurs at a faster rate, however, with a time horizon of 2030. Cities become denser, but with focus on the development of green spaces, green roofs and walls, community gardens and urban agriculture, with species, varieties and cultivation practices chosen in accordance with local conditions and climate change. The development of these “natural” amenities in the cities is a pull factor for populations, thereby helping to limit urban sprawl, and reduces the environmental impacts of densification. Our biodiversity scenario adopts an objective of “sustainable” urban density for inhabitants and for local biodiversity. The density thresholds are defined in accordance with local contexts and are based on objectives of improving quality of life, and of protecting and developing biodiverse and interconnected green spaces. For each urban hub, planning policies are designed to balance the benefits of densification and those associated with the development of more land-consuming open mosaic landscapes combining different types of land use without fragmenting ecosystems.

➤ The assumptions of a shift from private cars to public transport in the “Ville contenue” scenario are also included in our scenario for 2030, along with mitigation measures such as wildlife bridges and tunnels, and greenways to provide ecological corridors and enhance the well-being of urban populations. Last, our scenario is based on less resource-hungry modes of production, consumption and urban living, to reduce local pressure on resources, via reduced water consumption and waste production at local level, for example, and the development of local food systems at regional level.

8.4 Protected areas and forests: essential components of a biodiversity scenario

➤ The Energy, Agriculture & Food and Urbanisation components of the biodiversity scenario flesh out the outline scenario presented in section 3. That said, the assumptions relative to these components are not sufficient in themselves to reach the objective of “zero net biodiversity loss”. They do not say much about zones of special importance for biodiversity conservation, which are strongly protected under the outline scenario.

➤ A first dimension missing from our scenario concerns the future of protected areas. In 2019, the network of terrestrial protected areas represented 29.5% of the total surface area of France, a proportion very close to the 30% target set by the government for 2022. However, only 13.5%

of terrestrial areas in metropolitan France were designated as protected areas, and just 1.39% were strongly protected (MTES 2020). The Aichi target for protected areas is the one most easily reached by signatory countries as it is easy to create protected areas without implementing any genuine protective measures, or to include sparsely populated areas, sometimes with little true benefit for biodiversity. The capacity of a network of protected areas to contribute to the objective of “zero net biodiversity loss”, thus depends upon the distribution of these areas across the territory, the way they are managed, their connectivity and their protection levels. The choice of protection levels, and of authorised (or prohibited) human activities, must be decided in accordance with the characteristics of each territory, balancing conservation objectives on the one hand and social and economic objectives on the other.

➤ The future of forests is a second dimension missing from our scenario, the associated issues being only briefly mentioned in the Agriculture and Energy components. Forests cover 31% of the surface area of metropolitan France (INRAE, 2019) and forest cover increased by 120,000 hectares between 2006 and 2015, notably due to agricultural abandonment (Denardou et al., 2017). Land take for urban and infrastructure development sometimes leads to the destruction and fragmentation of habitats, notably small forested areas. French forests are generally better protected than other ecosystems; they account for 37% of the land designated as terrestrial protected areas in metropolitan France (Léonard et al., 2019). Yet the national assessment of the state of conservation of habitats and species of community interest over the period 2007-2012 indicates that for the French mainland ecosystems assessed, more than half of all forest plants, 17% of forest birds and 7% of forest mammals are endangered (EFESE, 2019). Climate change is affecting, and will continue to affect French forests by increasing the associated natural risks (storms, drought, fires, pests and pathogens) and by modifying the species distribution ranges (ibid).

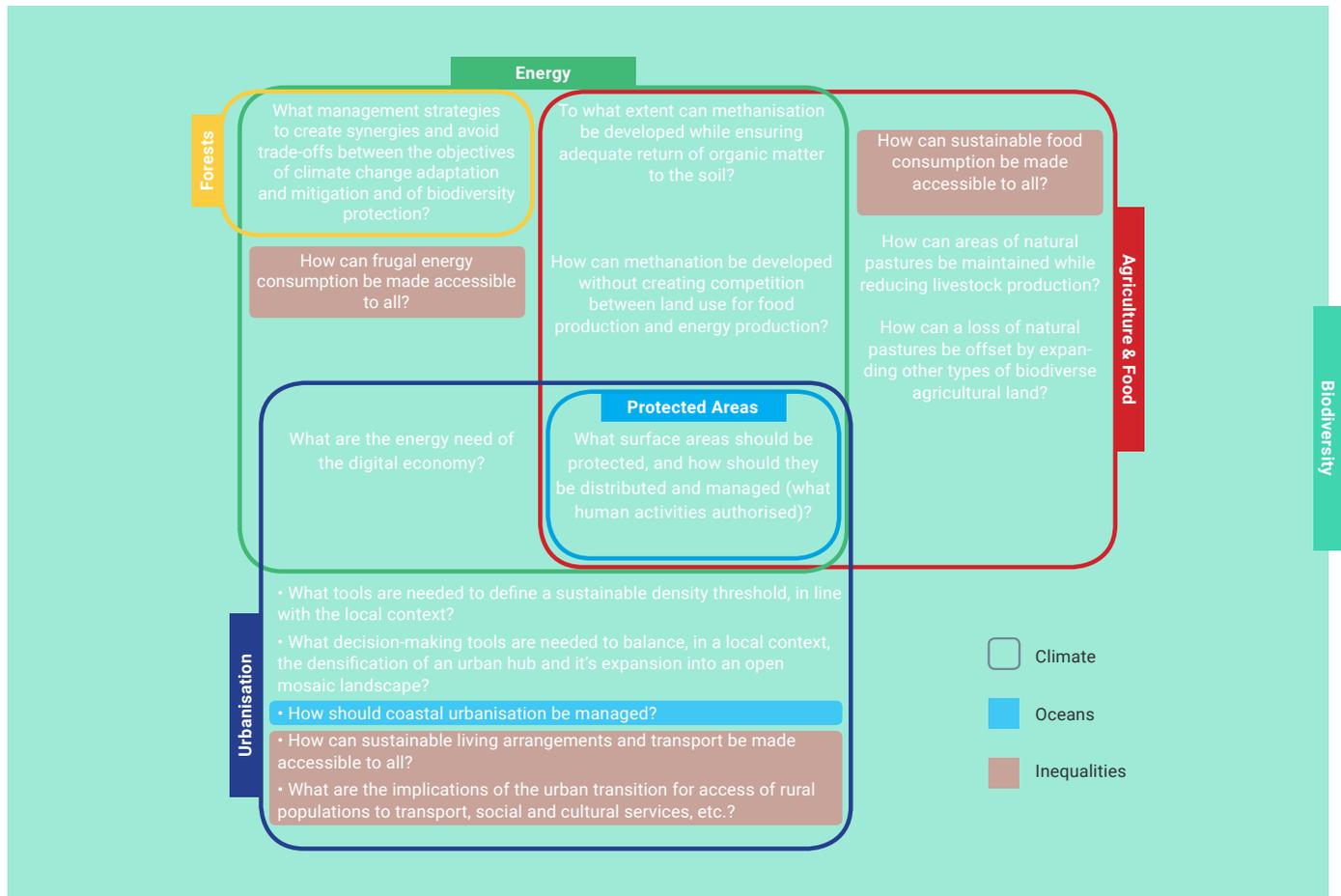
➤ Wood energy already accounts for nearly 40% of renewable energy production (MEEM, 2016) and the négaWatt scenario projects that wood energy production (in TWh) will increase by 60% between 2010 and 2030. Our own scenario does not make assumptions about the scale of wood energy development, as its implications for biodiversity are too uncertain. The timber industry, potentially stimulated by demand for biobased materials, raises the same questions. Beyond substitution effects (wood energy in place of fossil fuels and biomaterials in place of steel or concrete) forests play a role in mitigating climate change through carbon storage in ecosystems (and wood products). For the future of forests, an important question concerns our capacity to devise and implement appropriate regional and national strategies and management methods for each forested area that create

the strongest synergies and the fewest potential trade-offs between the objective of adapting to and mitigating climate change, and that of protecting biodiversity and the diverse services it provides.

8.5 Cross-cutting uncertainties and research questions on a variety of sustainable development issues

➤ Our biodiversity scenario is incomplete as it does not consider the components of the energy, agroecological and urban transitions with uncertain implications for biodiversity, or the future of protected areas and forests, which deserve to be examined in greater depth. These uncertainties exist in addition to those identified in the previous section concerning the implications of the energy, agroecological and urban transitions for oceans, freshwater, climate and inequalities. Figure 8.1 shows these uncertainties, all of which are important research questions, highlighting how they overlap with each other across the various SDGs studied. These questions, key to the future of biodiversity but also of the climate, intersect across a variety of sustainable development challenges and hence across scientific disciplines.

Figure 8.1 The main uncertainties and research questions of the scenario



LOCAL TRANSITIONS, GLOBAL CHALLENGES

► Analysing how implementation of the biodiversity scenario in France would affect the capacity of other countries or regions, and the world as a whole, to attain the sustainable development goals, necessarily raises the reverse question, i.e. that of how the rest of the world might hinder or facilitate implementation of the scenario in France. The international implications of a scenario for France, which occupies 1.3% of the earth's surface and represents less than 1% of the world population, are necessarily limited, given the global scale of the challenges linked to biodiversity, food security and climate change. For example, a decrease in French greenhouse gas emissions cannot significantly modify climate scenarios. The implications of our scenario for other countries or regions and for the earth as a whole only become fully meaningful if the transitions and transformations it involves take place on a pan-European scale at the very least. Moreover, given the importance of the Common Agricultural Policy (CAP) in shaping the priorities of the French farming sector, it will be impossible to implement the agroecological transition imagined for France over the next ten years unless it is Europe-wide. If we assume that transformations forming the basis of the biodiversity scenario are not only French but also European, or even broader in scale, the implications for the SDGs in other regions or on a global scale are numerous. The agroecological and energy transitions in particular, generate cross-scale interactions decisive for global biodiversity.

9.1 Agroecological transition and global food security

► For other regions, the implications of an agroecological transition that restores French or European plant protein self-sufficiency are considerable, both for biodiversity and climate change. Plant protein imports for animal feed are the main cause of French and European imported deforestation, and accounted for 44% of imported deforestation in the European Union in 2008 (European Commission, 2013). Pendrill et al. (2019) estimate that imported deforestation represented around one-sixth of the European Union's food carbon footprint over the period 2010-2014. More generally, changes in eating habits (less waste and fewer animal products) and livestock rearing practices are central to all pathways towards attainment of the Biodiversity and Climate SDGs on a global scale, since

29-39% of deforestation-related carbon emissions over the period 2010-2014 were driven by international trade, mainly in beef and oilseeds (Pendrill et al., 2019).

► The drop in French agricultural exports under the biodiversity scenario, mirroring that of Afterres2050, suggests a potential imbalance between food supply and demand at global level, especially if the agroecological transition occurs on a European scale.²⁵ Afterres2050 assumes that sub-Saharan agriculture will develop very rapidly, enabling the region, whose population is set to double between 2010 and 2050 (UN, 2019), to approach food sovereignty by 2050. In Afterres2050, the grain surplus available for export is therefore earmarked for North Africa and the Middle East to take account of climate change and the limited availability of arable land in these regions. The assumption of rapid agricultural development in the countries of sub-Saharan Africa, themselves severely affected by climate change, raises crucial issues for the organisation of world trade. With regard to biodiversity more directly, agricultural expansion on this scale in sub-Saharan Africa poses numerous questions about changes in land use, forested areas in particular, the methods used to increase yields (green revolution with a sharp increase in inputs, or agroecological revolution?), and changes in eating habits, and hence the amount of agricultural land needed for livestock production.

9.2 Energy transition and the digital economy: a new geography of strategic resources

► The growth of renewable energies in the biodiversity scenario is dependent on the extraction of growing quantities of metals not available in Europe to build energy infrastructures such as wind turbines, solar panels and batteries. Giurco et al. (2019) have estimated the quantities of lithium and cobalt, used in batteries,²⁶ and silver, used in solar cells, required for a global scenario that would limit global warming to 1.5°C in 2100, in line with the Paris agreement. Under this scenario, 100% of energy is from renewable sources (with solar power providing one-third of the total) and land transport is largely powered by electricity (55% of energy used in road transport). The scenario has several variants which explore the potential associated with more efficient use of materials and substantial advances in component recycling.²⁷ Aggregate demand for silver over the period 2015-2050, for solar

²⁵ France is currently the world's fifth largest agri-food exporter, with cereals accounting for most of the trade surplus (mainly towards Europe, North Africa and the Middle East). Under the Afterres2050 scenario, the trade surplus falls by around 15% in terms of energy value between 2010 and 2050. Today, the cereals traded within Europe are used mainly as animal feed. A drop in animal-based food consumption throughout Europe and a more grass-based diet for ruminants would make this trade unnecessary (Solagro, 2016).

²⁶ Under the scenario of Giurco et al. (2019), the main energy storage technologies are hydrogen storage and pumped hydroelectric storage. Lithium batteries, important for transport and on-board systems, account for 6% of energy storage.

²⁷ Between 2015 and 2050, the silver and lithium recycling rates increase from 0% to 81% and 95%, respectively, and that of cobalt from 90% to 95% (Giurco et al., 2019).

cells alone, corresponds to 50% of existing silver reserves. Aggregate demand for cobalt and lithium is greater than total existing reserves,²⁸ under all variants for cobalt, and under all variants except that including massive recycling, for lithium.

➤ The development of renewable energies is radically modifying the geographical origin of strategic raw materials for energy production, with geopolitical consequences, but also social and environmental impacts for local communities (Giurco et al., 2019). Their extraction and treatment are major sources of habitat degradation and pollution (Table 9.1). The scenario of Giurco et al. (2019) highlights the key importance of advances in recycling for the energy transition; it is also based on strong energy conservation and efficiency assumptions, with a 26% projected decrease in global final energy demand between 2015 and 2050. Developments in the

digital economy, whose implications have already been examined for the urban transition, will be decisive in this respect. The Shift Project, based on data from Andrae and Edler (2015), estimates that world energy consumption for the digital economy doubles every eight years and will further accelerate if no efforts are made to improve energy conservation (The Shift Project, 2019).

Table 9.1 Environmental health impacts from mining of battery materials

	Main producers	Environmental health impacts
Graphite	<ul style="list-style-type: none"> ➤ Chine : 65% ; ➤ India : 15% 	<ul style="list-style-type: none"> ➤ China : Air pollution from graphite dust, leading to respiratory ailments, water pollution from acids into local water sources including drinking water
Lithium	<ul style="list-style-type: none"> ➤ Australia : 40% ; ➤ Chile : 35% 	<ul style="list-style-type: none"> ➤ Australia : Large volumes of waste rock, high water use ➤ Argentina & Chile : Water pollution and depletion ; leaching, spills or air emissions of chemicals
Cobalt	<ul style="list-style-type: none"> ➤ Democratic Republic of Congo : 50% ; ➤ Chine, Canada, Russia et Australia : around 5% each 	<ul style="list-style-type: none"> ➤ DRC : Air, soil, and water pollution leading to heavy metal contamination of communities, health impacts including thyroid conditions, respiratory ailments and birth defects
Phosphate rock	<ul style="list-style-type: none"> ➤ China : 45% ; ➤ Morocco & Western Sahara : 13% ; ➤ US : 12% 	<ul style="list-style-type: none"> ➤ China : large volumes of waste rock, contamination of water with uranium, arsenic and cadmium with human health impacts ; ➤ Namibia : Potential risk for seabed mining
Lead	<ul style="list-style-type: none"> ➤ China : 50% ; ➤ Australia : 13% 	<ul style="list-style-type: none"> ➤ China : Heavy metal contamination of water, soil and plants with lead and cadmium ; serious human health impacts especially for children.

Source : Florin et Dominish (2017)

²⁸ Reserves are the share of total resources that can be extracted under current conditions of cost-effectiveness.

SOCIETAL TRANSFORMATIONS UNDER THE BIODIVERSITY SCENARIO

► The biodiversity scenario is based on rapid changes in our agricultural model, our eating habits, our energy system, our modes of transport, our residential choices and our biodiversity conservation strategies. These changes represent major societal transformations as they affect our relationship with nature. Sustainable consumption and production are a key dimension of all pathways leading to the realisation of the scenario. Reversing current trends in land take and in agricultural chemical inputs are two very interesting examples of transformations towards greater sustainability. First, pollution caused by chemical inputs and land take are among the primary factors of biodiversity loss in metropolitan France. Second, public and private stakeholders can act on these drivers of biodiversity loss at national level. Finally, while the reduction of chemical inputs and the deceleration of land take have been on the national political agenda for more than ten years, no real progress has yet been made.

► Transformation is initiated through a process of decision-making, be it by consumers, producers, citizens or public actors. This decision-making is shaped and constrained by factors of different kinds. These factors reflect the decision-makers' preferences, which are guided by their values (V), the institutional context, i.e. the formal and informal rules (R) governing their actions, and last, their knowledge-based understanding of the world (K) (Colloff et al., 2017). The *vrk* (values-rules-knowledge) approach, used here to analyse the transformations needed to reduce chemical inputs and land take, is a diagnostic method to identify not only the obstacles to transformation, but also the levers of change. The factors shaping the decision-making frameworks interact and co-evolve. For example, new knowledge or new laws may produce a shift in values which, in turn may drive institutional change or give new visibility to knowledge that was previously overlooked in the decision-making process.

10.1 Frugal use of chemical inputs: a broadly agreed objective challenged by the established farming and food system

► In the biodiversity scenario, mineral nitrogen consumption is halved, and that of crop protection products is reduced four-fold by 2030. These changes

rely on transformations that are now under way but at a too slow pace to achieve the “zero net biodiversity loss” objective by 2030. While conversions to organic farming have progressed rapidly over the last twenty years in France,²⁹ there is no sign of a reduction in the use of pesticides³⁰ despite this being a longstanding public policy objective at both European (EU Water Framework Directive, Reach Directive) and national levels (first national health-environment plan in 2004, Ecophyto 1 and 2). For example, the “Ecophyto 2018” plan adopted in 2008, which aimed to halve pesticide use within ten years “if possible”, failed not only to bring down levels of use but also to reduce water pollution (Hossard et al., 2017). The Ecophyto II plan adopted in 2015 pushes back the 50% reduction target to 2025, but the intermediate 25% target for 2020 has not been reached and there are currently no signs of any downtrend.

► Eating habits in France have been changing steadily since the 1960s. Health concerns have played a growing role since the 2000s, notably following the BSE crisis, with environmental concerns emerging more recently. According to the annual survey by the French Agency for the Development and Promotion of Organic Farming, household purchases of organic products increased by 22% annually between 2013 and 2018. In 2019, 59% of organic consumers reported buying organic products for health reasons, 51% for their quality and taste, and 45% for environmental reasons. Moreover, 82% of the French people interviewed believe it is important to develop organic agriculture, and 83% trust the organic farming sector. The share of French people who consume organic products on a daily basis remains small, however, and is increasing slowly, from 10% in 2015 to 14% in 2019. In parallel, while the market share of organic products in household food consumption more than doubled between 2012 and 2018, it remains marginal, at 4.8% in 2018 (Agence Bio, 2019).

► Table 10.1 presents the main obstacles to the reduction in chemical inputs classified according to their origin: values, institutions (or rules) or knowledge. The values liable to hold back a reduction in chemical inputs, on the part of both consumers (abundance, appearance of fruit and vegetables) or producers (high-yield agriculture, “well-tended land”) are counterbalanced by the emergence

²⁹ The share of French utilised agricultural area (UAA) used for organic farming increases from 7% in 2018 to 50% in 2030. It rose by 16% per year on average between 2012 and 2018 (EUROSTAT, 2020a), and the biodiversity scenario assumes that it will increase three times faster between 2020 and 2030.

³⁰ Pesticide use, measured in tonnes of active substance per hectare, and the consumption of nitrogen fertilizers in France are close to the European average (EUROSTAT, 2020b).

of new values. These new values place emphasis on authenticity, local production and supply,³¹ and quality. They are accompanied by an increasingly negative perception of processed foods and increasingly favourable attitudes towards environmentally-friendly farming practices.

➤ Institutional obstacles represent a much greater challenge due to their systemic nature. For consumers, the price difference between conventional and organic products is narrowing, and their local overall accessibility is increasing, thanks notably to the growing range of organic products sold by major supermarket chains. Moreover, in the biodiversity scenario, as in Afterres2050, French households buy slightly less food by reducing overconsumption and waste, and by consuming fewer animal-based products and processed foods. The food price increases resulting from improved quality (organic products and other quality labels) are thus offset by volume and substitution effects, and average household spending on food remains unchanged. So under our scenario, prices and income inequalities are not in themselves an obstacle to increased consumption of organic products. That said, inequalities of access to organic food and, more generally, to the dietary habits envisaged in our scenario, are the results of numerous demographic and socio-cultural factors, and cannot be attributed to price and income effects alone. They are also linked to nutritional education, cooking skills and living conditions. For example, the downtrend in meat consumption over the last 20 years in France has been accompanied by a reversal of its sociological characteristics. Traditionally, it was the wealthiest households that ate the most meat, but in 2016, people in higher-level occupations ate 113 grams of meat per day on average, and manual workers 151 grams per day (Tavoularis and Sauvage, 2018). Another example concerns time spent cooking food. Women in the lowest socioeconomic categories spend more time cooking than women with higher incomes, but female clerical and manual workers use fewer raw and fresh ingredients than women in higher-level occupations (Méjean et al., 2017).³⁵

➤ With regard to food production, the rules-based obstacles are linked to the very structure of the farming and agri-food industries. Farmers are very dependent upon cooperatives which impose demanding yield criteria in return for expert advice and, in some cases, crop protection products to help achieve these yields. Strict specifications are imposed to comply with the standardised product requirements of supermarkets and the food processing industry. These highly structured farming systems are very “path-dependent” and affected by powerful lock-in mechanisms (Vanloqueren and Baret,

2009). Analysing the different conversion pathways towards organic farming and integrated pest management, Lamine et al. (2009) show that the transformations made by converting farmers extend well beyond changes in farming practices and modify their “relations with other “objects”: soil, outputs, crop rotation, work organisation, sales, social networks, skills learning” (Lamine et al., 2009). The shift away from conventional agriculture is made more difficult by the interdependence of the entire agri-food system; production systems cannot be transformed without corresponding changes in modes of processing, distribution and consumption, and vice-versa. The case of pulse crops is a good illustration of this; their development is dependent on transformations and innovations both upstream and downstream of the farming and food system (Box 10.1).



³¹ The preliminary findings of the INRAE “Eating habits during the Coronavirus epidemic” survey show that local products distributed via local supply systems were greatly appreciated by French consumers during lockdown, for reasons of confidence, solidarity and health (RMT Alimentation locale, 2020). This tendency, which will need to be monitored over time, appears to confirm that crisis situations are conducive to more rapid changes in behaviour.

³⁵ Few differences between occupational categories are observed for men (Méjean et al., 2017).

Table 10.1 Obstacles to more frugal use of pesticides and chemical fertilizers

	Consumers	Producers	Public actors
Values	<ul style="list-style-type: none"> ➤ Importance attached to the abundance and appearance of food products 	<ul style="list-style-type: none"> ➤ Positive image of a productive, high-yield agriculture 	
		<ul style="list-style-type: none"> ➤ Positive image associated with “well-tended land”³² 	
Rules	<ul style="list-style-type: none"> ➤ Price is still the main obstacle to organic produce consumption³³ ➤ Insufficient local supply of organic produce³⁴ 	<ul style="list-style-type: none"> ➤ Power asymmetries between farmers, cooperatives, processing industries and distributors ➤ Risks and uncertainties associated with changes in farming practices. Risk-taking held back by low farm incomes ➤ Difficulty of obtaining certificates of sustainable farming practice (high costs and demanding regulations) ➤ Difficulty of gaining a foothold in organic food distribution networks ➤ Difficulty of obtaining farmland and bank loans for small-scale farmers 	<ul style="list-style-type: none"> ➤ Few restrictive public policy instruments, be it at local, national or European level (CAP)
	<ul style="list-style-type: none"> ➤ Lack of transparency in the agri-food industry about the origin, composition and quality of their products 	<ul style="list-style-type: none"> ➤ Lack of alternatives to pesticides ➤ Lack of technical and management training in non-conventional methods 	
Knowledge	<ul style="list-style-type: none"> ➤ Lack of knowledge on the adverse effects of pesticides on the health of farmers and consumers ➤ Lack of knowledge on the “cocktail” effect: little available data on possible interactions between the components of mixed chemical substances and their health effects 		

³² As pointed out by Roussary et al. (2013), “the presence of weeds and pests – on farmers’ own crops or in neighbouring fields – conveys the impression that they “aren’t doing their job properly” or that they are “letting things run wild”. Conversely “technical proficiency” and “well-tended land” give a positive image of their farming skills”.

³³ Organic production costs are higher on average. They are further increased by the costs of controls and certification. In addition, the collection and distribution circuits for organic produce are not large enough to achieve economies of scale comparable to those of conventional circuits.

³⁴ Despite a decline in the share (in monetary terms) of imported organic produce consumed in France, imports still accounted for 31% of the total in 2018 (Agence Bio, 2019).

10.2 Frugal land use: a secondary objective

➤ Under the biodiversity scenario, the growth of urban sprawl and land take is reversed.³⁶ The scientific assessment of land take conducted in 2017 at the request of the French authorities testifies to the importance of this issue in public debate (Desrousseaux et al., 2020). Citizens and decision-makers are concerned about the role of land take both in biodiversity loss³⁷ and in farmland loss.

➤ Estimates of the rate of land take in France vary according to the methods used. According to the Teruti-Lucas survey, in 2014, artificial land surfaces³⁸ accounted for 9.3% of French land area (5.1 million ha.),³⁹ while European data from Corine Land Cover give an estimate of 5.3% in 2012 (3 million ha.) placing French around the European average. Both studies observe an accelerating tendency in France, with a rapid increase in land take in the 2000s, a slowdown between 2009 and 2014, followed by a resumption in 2015 and 2016. With an estimated rate of increase of around 0.5% per year, France is close to the European average, ranking between Spain and Germany, where rates are respectively five times higher and two times lower (Desrousseaux et al., 2020).

➤ Desrousseaux et al. (2020) show that changes in French land cover are due largely to two factors: urbanisation and agricultural abandonment. According to Teruti-Lucas data, two-thirds of land take between 2006 and 2014 involved loss of agricultural land. However, this does not imply that agricultural abandonment is a consequence of urban sprawl, since over this same period, more agricultural land was lost to forest and natural areas (–817,000 ha.) than to land take (–524,000 ha.), with very different impacts on biodiversity in terms of reversibility. In any case, the impact of current trends in land use on ecosystems is considerable, since sealed areas have increased more rapidly than artificial areas as a whole. Moreover, land take has been more intense in the vicinity of towns and cities, where land is often high-quality arable farmland, and in coastal natural areas and wetlands (Desrousseaux et al., 2020; Chery et al., 2014). Last, peri-urbanisation has led to the expansion of urban sprawl into agricultural, forested and natural areas, with major impacts on biodiversity.

➤ Table 10.2 gathers the main obstacles to reduction of land take classified according to their nature (values, rules, knowledge). French people have a marked preference for single-family housing. In a CREDOC survey in 2004, 87% of the French people interviewed reported a preference for a single-family home (56% a detached house, 20% a house in a housing development, and 11% a small urban single-family home), and for 58% of respondents a garden is a very important part of a home (Djefal et Eugène, 2004). These preferences do not appear to have changed: single-family houses accounted for 55.4% of homes in metropolitan France in 2017, compared with 55.8% in 2007 (INSEE, 2020). This is an important driver of land take since 94% of land taken for housing over the period 2006-2014 was for newbuild houses (with a garden) (Desrousseaux et al., 2020).



³⁶ The term land take refers to the transformation of grassland, wetlands, farmland and forests to develop built and unbuilt spaces (housing, industrial buildings, construction sites, quarries, mines, waste dumpsites, etc.) but also green spaces (parks and gardens, sports and leisure facilities, etc.).

³⁷ The 2018 Biodiversity French governmental plan sets a target of “zero net land take” by 2050 (MTES, 2018).

³⁸ Artificial land surface includes: urban fabric; industrial, commercial and transport units; mine, dump and construction sites; artificial non-agricultural vegetated areas.

³⁹ According to Teruti-Lucas, the 5.1 million hectares of artificial land surfaces in 2014 include 1 million ha. of buildings (+22% with respect to 2006), 2.5 million ha. of sealed or stabilised surfaces (+14% with respect to 2006), and 1.7 million ha. of grassed or bare unsealed surfaces (+4% with respect to 2006). The reversibility of land take depends on the type of land cover. Reversal is much easier for stabilised surfaces (including railway lines) and for grassed or bare surfaces (Desrousseaux et al., 2020).

Table 10.2 Obstacles to reduction of land take

	Private actors	Public actors
Values	<ul style="list-style-type: none"> > Desire for a house and garden Dislike for high-density housing 	<ul style="list-style-type: none"> > Urban growth seen as a sign of success for local government
Rules	<ul style="list-style-type: none"> > Housing demand driven by population growth and decohabitation > Growing numbers of second homes and vacant properties > Relocation of jobs in suburban and peri-urban areas > Development of logistical activities (warehouses and related parking areas and access roads) > Rapid development of the leisure industry, a major land consumer > Urban sprawl favoured by rising housing costs with respect to transport costs > Urban sprawl favoured by high cost of renovation compared to new build > Higher anticipated income from urban land use than from agricultural land use 	<ul style="list-style-type: none"> > Public stimulus for housing construction to address housing needs > Importance of creating jobs in local communities > Retention of building land in urban areas encouraged by the tax regime for undeveloped land > Local zoning policies place decision-makers under strong pressure from owners and developers > Mechanisms for offsetting land take are limited and rarely applied > Complexity of existing instruments and the high cost of tax or monitoring implementation > Limited scope of application of impact assessments as only required for large surfaces > Impacts on soil quality rarely considered in project impact studies or in environmental assessments of planning documents > Lack of public consultation in urban planning
Knowledge	<ul style="list-style-type: none"> > Lack of knowledge on the environmental consequences of our lifestyle choices 	<ul style="list-style-type: none"> > Lack of knowledge on existing legal and political instruments to limit land take > Lack of knowledge on the state of the environment, soils especially

Note : The tables presented in this document which do not give a source are based on participant discussions and expert interviews before or after the workshop. Table 10.2 is based not only on discussions and expert opinion, but also on the analysis of the determinants of land take by Desrousseaux et al. (2020).

➤ This values-led driver of land take is combined with major demographic and societal trends, such as population growth, decohabitation and the growing number of second homes, which stimulate demand for housing.⁴⁰ Economic drivers, such as the rising cost of housing relative to transport and the growth of activities that use peri-urban land (logistical activities, recreational sector) are in turn increasing land take, the process of peri-urbanisation especially. Desrousseau et al. (2020) show that public policies can also be an obstacle to more frugal land use. State intervention in this area aims primarily to support housing construction as a means to address the housing shortages that primarily affect the most disadvantaged French households. Moreover, the instruments for containing land take available to local authorities (taxation, zoning) are easy to circumvent, non-compulsory and managed disparately at different territorial levels, making them largely ineffective. These instruments may even do more harm than good in some cases. For example, the “development tax [applicable to all projects subject to urban planning permission] is seen more as an opportunity for municipalities than as a real lever for reducing land take, as it was introduced to provide municipalities with funding for public amenities” (Desrousseau et al., 2020). Likewise, the decentralisation of zoning policies places local authorities under pressure from developers and landowners and creates competition between communities to attract business and jobs.

10.3 Knowledge: a powerful lever of change

➤ Knowledge has an important role to play in removing the obstacles to change by enabling stakeholders to revise their values and preferences and to modify the formal and informal rules governing their decisions. Box 10.1 illustrates the role of knowledge as a lever of change for the production and consumption of pulse crops which play a central role in low-input agriculture. By providing insights on the consequences of choices and by driving technological and societal innovation, knowledge and its appropriation by stakeholders broaden the range of possibilities for decision-making and action. Public debate and consumer information on the implications of diet for personal health and the environment have already transformed the values associated with food and eating habits. However, the overwhelming majority of households still do not see a link between their residential choices and their environmental impact. More information on the relationship between land use and residential choices (but also modes of transport or choice of supply networks) would probably not have any short term impact on household behaviours. It would nonetheless foster greater public consultation and engagement in urban planning projects.

➤ Desrousseau et al. (2020) show that a much more comprehensive knowledge of land and soil is key to designing and implementing public policies capable of responding to housing needs while reducing land take and protecting biodiversity. This knowledge includes not only inventory data on land use, but also an understanding of the biogeochemical functioning of soil. For example, the rehabilitation of vacant spaces, including vacant housing, is a powerful lever for controlling land take and addressing housing needs. These spaces can be used directly for housing, but also for green spaces which make towns and cities more attractive. This enhances inhabitants’ well-being, thereby limiting urban sprawl and city-centre land abandonment. However, as highlighted by Desrousseau et al. (2020), active rehabilitation of vacant spaces is held back by a lack of data. While the number of vacant dwellings is known,⁴¹ there is still no inventory of brownfield sites or vacant office buildings. The authors also highlight a severe lack of data on the state of the environment, soils in particular, which makes it impossible to measure the potential impact of land take associated with conversion projects. Greater knowledge would help local public decision-makers to avoid land take, or limit or offset its impact, by enabling them to choose the best possible land use options in accordance with different land and soil characteristics.

➤ Much of the knowledge mentioned above can be used by the actors involved if placed in context and adapted to different spatial scales. The agroecological transition, for example, is built upon knowledge of agro-ecosystems at farm, landscape and regional levels (Meynard, 2017). When the aim is to limit the environmental impacts of human activities, the wide diversity of situations becomes a key component in several respects. First, preserving the heterogeneity of the “living environment” offers a means to take practical action. For example, pulse crops are used to fix atmospheric nitrogen, and nature-based solutions such as swales or “rain gardens” which capture rainwater at source and facilitate infiltration limit disruptions to the water cycle caused by urbanisation. Second, the question of balancing the different objectives associated with the use of natural resources (employment, income, mitigating climate change, protecting biodiversity and water resources, etc.) is posed differently on different spatial scales and must take account of each distinct social and ecological context.

⁴⁰ The number of second homes rose by 11% between 2007 and 2017 (INSEE, 2020).

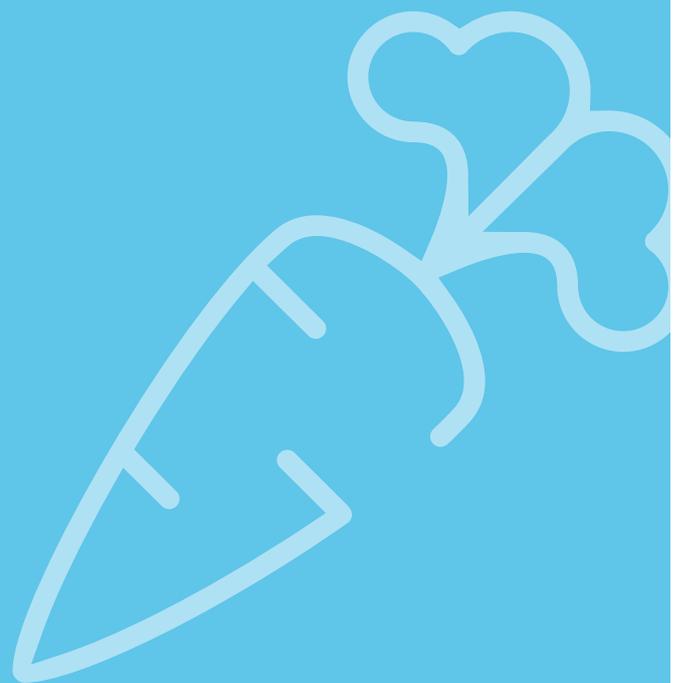
⁴¹ The number of vacant dwellings in France rose from 1.8 to 2.8 million between 1982 and 2017 (INSEE, 2020).

Box 10.1 “Unlocking” pulse crop production and consumption: the role of knowledge

- ▶ Pulse crops have numerous advantages. They fix nitrogen from the atmosphere and provide a protein-rich food source for humans and animals, they enhance soil fertility and are very valuable as intermediate crops. Pulse-based crop diversification also reduces the need for herbicides and fosters greater functional diversity of agricultural ecosystems (Magrini et al., 2018; Schneider and Huyghe, 2015). The development of pulse crops would help to mitigate agricultural greenhouse gas emissions by reducing the need for nitrogen fertilizers, but also by offering a food substitute for meat. But pulse crops accounted for just 2.1% of cultivated areas in the European Union⁴² in 2015, compared with 50% for cereals (EUROSTAT, 2016).
- ▶ Magrini et al. (2018) have studied the obstacles holding back the development of pulse production and consumption in France. They point up the role of knowledge as a lever of change throughout the farming and food system. First, farmers are poorly informed about the benefits of diversification and the use of pulses in crop rotations. Their management tools focus on annual yields rather than on longer term benefits of this kind. Agricultural research, advice and training are important levers for spreading knowledge about the agronomic value of pulses, but also for increasing and stabilising yields.
- ▶ Second, there are few economic incentives for producing pulse crops. National and CAP subsidies have been irregular and centred on fodder legumes (Solagro, 2015); they are currently insufficient to support the development of pulse production. The creation of new markets for pulse crops depends largely on the capacity of farming cooperatives to structure new supply chains to increase their market value. This calls for commercial innovation, but also logistical adaptation (for storage especially) and advisory services for farmers to promote crop diversification.
- ▶ Market prospects depend ultimately on consumer demand. Pulses are a cheaper protein source, on average, than meat (Solagro, 2015), they are rich in fibres and complex carbohydrates and have a low fat content. Research could be conducted to improve the bioavailability and dietary appeal of plant proteins (their digestibility in particular) and to associate them with other types of food to achieve the same nutritional properties as animal protein (Laleg et al., 2017). While pulses are an important food source in a low animal protein diet, there is relatively little consumer information on their health benefits in France.

Pulses were traditionally classified as starchy foods in the food pyramid promoted by the PNNS,⁴³ and were only moved to the category of protein-rich foods in 2017.

- ▶ Moreover, many consumers do not know how to cook pulses; innovative processing methods could be developed by the food industry to increase their appeal by improving their nutritional qualities, their taste and their convenience (by reducing cooking times, for example). Last, informing consumers about the contribution of pulses to a more environmentally sustainable diet could be a useful way to promote sales and encourage healthy eating.



Source: adapted from Magrini et al., 2018

⁴² Pulse crops accounted for 1.5% of cultivated areas in France in 2015 (EUROSTAT, 2016).

⁴³ Plan National Nutrition Santé (National Nutrition and Health Plan).

11.

INTEGRATED AND PARTICIPATIVE APPROACHES TO SUSTAINABLE DEVELOPMENT STRENGTHEN THE ROLE OF KNOWLEDGE IN TRANSFORMATIONS

► The biodiversity scenario was built around the objective of “zero net biodiversity loss” in the framework of Agenda 2030 recognising that a sustainable development pathway must address a wide range of environmental and societal challenges. Rather than envisaging direct actions to preserve and restore biodiversity, the first task in constructing the scenario was to consider the various drivers of biodiversity erosion. The scenario thus takes account of the interactions between biodiversity and those human activities with the greatest impact on its evolution, namely food, energy and urbanisation. By examining the implications of future trends in these activities for other SDGs, the scenario also takes account of interactions with the targets for oceans, climate, freshwater and inequalities.

► The interactions between SDGs are manifold; they take the form of synergies or trade-offs, and occur on multiple levels across time and space. For example, climate change mitigation is a component of the fight against biodiversity erosion. But given the considerable time needed for climate change mitigation measures to have a tangible impact on climate and hence on biodiversity, most of the synergies between these two targets will not become manifest until well after 2030. Moreover, climate change mitigation measures will have little impact on the climate or on biodiversity if they are limited to one country or one region alone. Nevertheless, certain actions to mitigate climate change will be beneficial to biodiversity by 2030. This is the case for all actions that encourage frugal use of natural resources. Others may result in trade-offs. For example, decarbonising our energy system through the massive development of renewable energy may contribute to biodiversity erosion, especially when this energy is generated from biomass.

► Given the brevity of their ten-year time horizon, the transformations required to realise this scenario are very radical. The obstacles to these transformations are linked both to the systemic nature of our modes of development and to the trade-offs that may exist between different development objectives. Knowledge and its appropriation by stakeholders play a key role in these transformations

by helping to redefine values and institutions. Yet while substantial knowledge of the interactions between socioeconomic systems and ecosystems is readily available, and has often been so for many years, the transformations themselves have barely begun. Moreover, emphasising the role of knowledge and its appropriation by stakeholders at both individual and collective levels may seem contradictory: knowledge production and appropriation necessarily take time, but preserving the environment is an urgent challenge. This urgency places local, national, European and international policies at the forefront. Public action is key to making the necessary investments and implementing the rules and incentive mechanisms required to realise these transformations and to manage the inevitable trade-offs.

► A growing body of knowledge has been made available in recent decades, but the efforts of the scientific community to elicit responses from policymakers have not been sufficient. The biodiversity workshop is one among a growing number of initiatives that provide opportunities for the scientific community to contribute more actively to societal transformations. The workshop findings reveal the value, for both scientists and stakeholders, of an integrated approach to the SDGs. Given the multiple synergies and trade-offs that exist between the sustainable development goals across time and space, it is important for public and private decision-makers (including citizens) to grasp the systemic – and hence necessarily complex and sometimes conflictual – nature of our modes of development.

► Integrated approaches to the challenges of sustainable development provide tools to guide stakeholders. Returning to the example of pesticide reduction, such approaches make it clear that reducing pesticide use does not simply come down to a choice between maintaining crop yields on the one hand or better water quality on the other. It generates direct benefits for water and biodiversity and preserves the services they provide over the long term. Pesticide reduction is also beneficial for coastal zones – in terms of ecosystems and economic activity – for oceans and for health. Indirectly, the implementation of alternative agroecological practices

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