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An overview of the 2017 report of the French academy of Sciences on biodiversity

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Abstract: In the present context of concerns for biodiversity, the French Academy of Sciences produced in 2017 a report entitled “Mechanisms of adaptation of biodiversity to climate change and their limits”. We briefly review here the production process and structure of the report, and summarize its conclusions and recommendations.

The conclusions emphasize the role of habitat fragmentation in the expected impact of climate change on biodiversity, in particular for organisms with limited dispersal abilities, and the disparities in species responses which must be taken to understand the future of species assemblages (“communities”) under different scenarios of climate change.

The recommendations cover the organization of biodiversity research and monitoring (development of observatories, key role of embedded time scales and modeling, integration of Human and Social Sciences), as well as critical domains such as Human, animal and plant health, agriculture and forestry policies, and management of the Environment.

Key words: biodiversity, climate change, global change, adaptation.

INTRODUCTION

In the present context of concerns for biodiversity, the French Academy of Sciences produced in 2017 a report entitled “*Mechanisms of adaptation of biodiversity to climate change and their limits*”. The purpose of this paper is to briefly review the production process and structure of the report, and to summarize its conclusions and recommendations, as presented by one of the authors (JDL) at the

Brazil-French Symposium on biodiversity held in Manaus (Amazonas, Brazil) from June 2 to 5 2018. The full version of the report is available (in French) at <http://www.academie-sciences.fr/fr/Rapports-ouvrages-avis-et-recommandations-de-l-Academie/mecanismes-adaptation-biodiversite-aux-changements-climatiques.html>.

The decision of producing this report obviously stemmed from the current concerns for environmental change. Current environmental issues are dominated by two major phenomena, both resulting from human activities: the ongoing and forecasted climate change (IPCC 2014) and

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the worldwide erosion and homogenization of biodiversity (Cardinale et al. 2012). The two phenomena have been analyzed for decades (Diaz et al. 2006, Stern, 2007) and have been now recognized as strongly linked (e.g., Bellard et al. 2012, Bálint et al. 2011, Oliver and Morcroft 2014). The adaptability of the living world to environmental changes raise a number of questions. The need of anticipating as much as possible the consequences on human societies of global change as a whole lead the Academy to develop this report to gather information and provide a point of view complementary to most available reports on global change. This is why this report is primarily focused on the adaptability of biodiversity to climate change. While much is known, as the report shows, the list of open questions (e.g., role of extreme climatic events, degree of resilience of a variety of ecological processes, complex interactions, predictability of ecological systems...) is large, and a special attention was put on the uncertainties of the various mechanisms and issues reviewed.

PRODUCTION OF THE REPORT

The production of the report was coordinated by Sandra Lavorel, Jean-Dominique Lebreton and Yvon Le Maho, members of the French Academy of Sciences.

A preliminary draft was first assembled and revised in a series of meetings of the Environment Committee, a permanent committee of the Academy, which gathers in a strongly pluridisciplinary way a variety of scientists and scientific fields implied in environmental science: Ecology, Climatology, Biology, Earth sciences, Chemistry, Paleontology, Physics, Hydrology, etc.

This first draft was then polished by a subcommittee, who met on January 17, 2017, and submitted for approbation to the Environment Committee.

The resulting version was amended and approved by vote by the whole Academy on June 27, 2017, and made available online in September 2017.

STRUCTURE OF THE REPORT

The report consists of 15 pages covering a general overview of the subject, conclusions, and recommendations, reviewed below, accompanied by 26 thematic sheets on specific topics.

These 26 thematic sheets review mechanisms underlying the degree of adaptability of biodiversity to climate change. They were prepared by 33 leading French experts. The 17 first sheets deal with mechanisms of adaptability at various levels of organization: individuals (6), populations (4), Ecosystems (7). The 9 other sheets cover the interface between biodiversity and human societies: mitigation (2), exploitation and management (5) and social adaptation (2). They were prepared under a common format (3-7 pages, 1 or 2 figures, 1 example) and layout (Description of the mechanism of topic, limits and solutions, uncertainties). Based on such expertise, these thematic sheets constitute a rich and homogeneous source of information on biodiversity in face of climate change, to be used in the future. Their full list is given in Box 1.

SUMMARY OF THE REPORT CONCLUSIONS

The main conclusions of the report are based on the fact that, among ecological mechanisms, “the dominant phenomenon induced by an increase in temperature is the shift towards the poles or higher elevations of the area occupied by each animal of plant species”. From this basic statement, stem the following conclusions:

- It is important to consider the capacities of adaptation of living organisms when they cannot move, in particular under the effect of landscape fragmentation.

Box 1 - Organization, titles and authors of the 26 thematic sheets in the French academy of sciences report on Biodiversity

I. The biological mechanisms of adaptation to climate change

Individual level

- 1) Physiological adaptations in Vertebrates – *F. Angelier*
- 2) Mechanisms of adaptation of plants to climate change – *F. Tardieu*
- 3) Molecular mechanisms of adaptation to climate change: the impact of genomics – *M. Delseny*
- 4) Soil organisms – *J.-L. Chotte*
- 5) Phenotypic plasticity – *A. Charmantier*
- 6) Adaptations of insects change – *J. Casas & S. Pincebourde*

Populations and time scales

- 1) Adaptive answers to climate change – *O. Ronce*
- 1) Demographic and genetic mechanisms – *D. Couvet & F. Courchamp*
- 1) Changes in distribution area – *I. Chuine*
- 2) Biodiversity fluctuations at long time scales: estimation and climate impact – *P. Janvier*

Ecosystems

- 1) Mechanisms of re-assemblage in terrestrial communities – *W. Thuiller*
- 1) Mechanisms of adaptation in marine ecosystems – *D. Mouillot*
- 1) Adaptation of functioning in terrestrial ecosystems – *S. Lavorel*
- 1) Freshwater ecosystems biodiversity and climate change – *D. Gerdeaux*
- 1) Can coral reefs adapt to climate change? – *D. Allemand*
- 1) Mangrove swamps, anthropic and climatic pressures – *F. Fromard & A. Gardel*
- 2) The role of metagenomics to evaluate the capacity of adaptation of soil to environmental changes, in particular climate change – *P. Simonet*

II. Management and exploitation of ecosystems

Mitigation

- 1) Climate change mitigation by terrestrial ecosystems – *N. Viovy*
- 2) Mechanisms of mitigation of climate change by biological processes – *Ch. Rabouille, L. Bopp & M. Gehlen*

Exploitation and Management

- 1) Adaptation of agriculture to climate change – *J.-F. Soussana*
- 1) Managing soil biodiversity to improve agrosystem resilience and adaptation to climate change – *P. Lavelle*
- 1) The ecosystemic approach to fisheries for adaptation to the impacts of climate change and overfishing in marine ecosystems – *P. Cury*
- 2) Top predators in face of anthropogenic changes, overexploitation and climate change – *C. Le Bohec*
- 3) Management of temperate forests, climate change and biodiversity – *J.-L. Dupouey*
- 4) Agrobiodiversity, local selection, within - and between - species hybridization for adaptation to global change – *Y. Vigouroux*

Social adaptation

- 1) Managing tropical forest ecosystems in a changing climate – *B. Locatelli, J. Chave & E. Torquebiau*
- 2) Adaptation of human societies to climate change through coastal and marine ecosystem services – *H. Levrel*

- The individual adaptability through plasticity (...) and genetic adaptation (...) strongly vary among organisms.
- The expected diversity of the response of species to the various parameters of climate change induces disparities in the response of communities (species assemblages).
- Such disparities are already well documented, and taking them into account is absolutely needed to understand the future of species assemblages under different scenarios of climate change

RECOMMENDATIONS

The recommendations in the report were organized under 7 headings, ranging from issues dealing with the acquisition and dissemination of scientific knowledge on the effects of climate change through its consequences for biodiversity (the first 4 recommendations), to broader issues dealing with the consequences for human societies and priorities for adaptation to climate change and potential mitigation. While these recommendations were developed with specific reference to the French context, they are of general interest, would it be only for the responsibility of France towards intertropical biodiversity in overseas departments and territories (see rec. 7), among which what deals with biodiversity in French Guyana is obviously of special interest to Brazil. What follows is an abridged literal translation of the report recommendations.

- (1) *Biodiversity observatories: the complexity of mechanisms and the amplitude and variability of responses to climate change require that biodiversity observatories are developed, with appropriate staff and money resources. This development should be closely linked to fundamental research and modeling, and be accompanied by an effort on education.*
- (2) *Embedded time scales: it is of primary importance to take into account recent and current observations, at the scale of the century or less, together with observation at the scale of a millennium and above. For such an endeavor, interactions among ecologists, historians, archeologists and geologists should be reinforced.*
- (3) *Modeling: developing biodiversity scenarios based on observations requires an increased effort in modeling the dynamics of ecosystems, including agro-ecosystems and urban ecosystems.*
- (4) *Human and Social Sciences, and education: to facilitate the adaptation of human societies to responses of biodiversity to climate change, the input of Social and Human Sciences and the development of an appropriate education to sustainable development are needed.*
- (5) *Human, animal and plant health: in face of the increase in emergent pathologies induced by the observed temperature increase of 1°C and the worldwide development of transportation, linking*

¹ The “Museum national d’histoire naturelle” in Paris

research on public health and pathogen ecology must be accelerated and broadened.

- (6) *Agriculture and Forestry policies: concerning agriculture, the main problems are the need to develop adapted varieties, the expected distributional shift of pollinators and pests, and the adaptation to climate of perennial cultures such as vine. Concerning forests, "assisted migration" by planting adapted species could help limiting the risks of forest decay, a decay that would unavoidably be accompanied by an increased risk of forest fires.*
- (7) *Environment management: the interaction of potential effects of climate change on biodiversity with other factors, and the risk of threshold effects on some ecosystem services require interventions to limit such factors: fishing quota, protection of marine areas, development of corridors facilitating the dispersal of organisms... Efforts of protection should in particular aim at the most fragile species: specialized species, with little plasticity, with slow demography, megafauna (large mammals, large terrestrial and marine reptiles, large raptors and seabirds...) and on the most sensitive ecosystems (wetlands, marine ecosystems, biodiversity hotspots - for France in particular overseas territories...).*

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AUTHOR CONTRIBUTIONS

Sandra Lavorel, Jean-Dominique Lebreton and Yvon le Maho coordinated the preparation of the report presented in this paper. They edited the thematic sheets written by the external experts, wrote the preliminary versions of the report introduction, and managed the revisions by the environment committee of the French Academy of Sciences.

Jean-Dominique Lebreton prepared an English summary of the report and presented it at the June 2018 conference in Manaus. This article is a revision by the three authors of this summary.

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