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FRENCH REPUBLIC

PARLIAMENTARY OFFICE FOR THE EVALUATION OF SCIENTIFIC AND TECHNOLOGICAL CHOICES

THE CONTRIBUTION OF SCIENCE AND TECHNOLOGY TO SUSTAINABLE DEVELOPMENT

Tome II: Biodiversity: The other crisis? The other opportunity?

Summary of the report of Mr. Pierre Laffitte and Mr. Claude Saunier, Senators

I. The biodiversity of the planet's ecosystems is deteriorating significantly

A. The assessment is disastrous …

1. The rate at which species are becoming extinct is speeding up

For the last two hundred years this rate has been 10 to 100 times greater than the natural rates of extinction. And the evaluation made by the international scientific community in 2000 shows that **by 2050 it could be 100 to 1,000 times greater depending on the species**.

2. Some biotopes are more particularly threatened

- Biodiversity in **humid zones and continental waters fell by 37% between 1970 and 2000.**
- **The pelagic food chain** of some marine environments in the North Atlantic has deteriorated: 7% of marine species have disappeared since 1950; the enquiry published in November 2006 in "Science" predicted that the North Atlantic's pelagic species would have virtually died out by 2050.
- 60% of coral is affected by human activity and 20% has disappeared in thirty years.
- Dry tropical forests are on the way to extinction (Madagascar, the Brazilian Atlantic forest, of which only 7 to 10% still remains).

3. European biodiversity, already heavily impacted by humanity, is also affected

- Continental waters suffer from pollution and the excessive use of water for agriculture, to the extent that the various species are unable to adapt to the hydrological cycles.
- The European Union has determined that, outside the zones protected by the "Natura 2000" directive, losses of biodiversity in avian fauna could reach 70%.
- In thirty years, the Beauce region has lost more than 30% of the organic compounds in its soil.

B. The traditional pressures are growing…

Since 1990, the ecological footprint left by humanity has been exceeding the reconstruction capacities of the planet's ecosystems.

As a result, we are now on the threshold of non-sustainable development.

If we continue on the current bases, humanity's demand in 2050 will be double the biosphere's production capacity.

1. Predation pressures

- **Industrial over-fishing leads** to the over-exploitation of halieutic species. It **also** destroys the equilibrium of the oceans' ecosystems:
  - **due to the large numbers of incidental species catches (by-catches),** which are just discarded and can be as much as 80% of the total catch,

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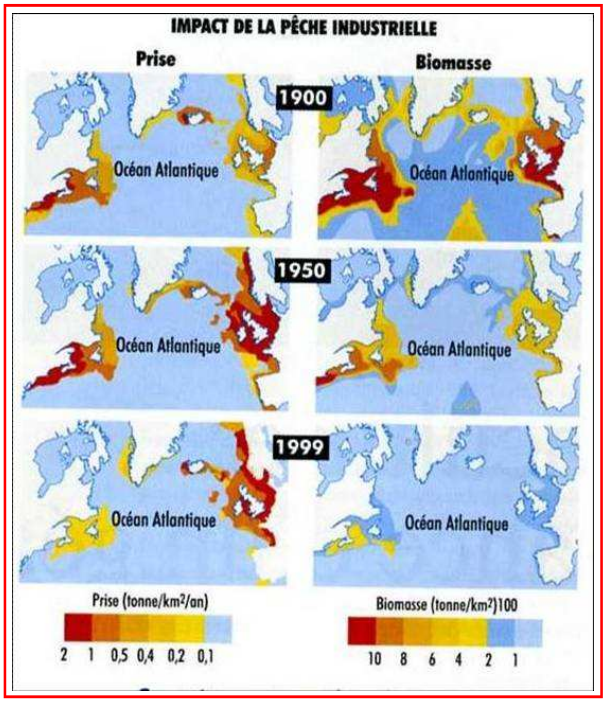
- **by its effect on the pelagic populations of the** ocean's **deeper regions**. In 20 years, the average depth of fishing has gone from 100 m to over 300 m. The unrestrained exploitation of these **species, which take more than sixty years to reach maturity, is leading to their depletion.**



- The development of open circulation marine aquaculture is a further source of damage:
  - the fish are fed with fish meal composed of alevins (from 1 to 3 kg of meal for 1 kg of aquaculture produce),
  - the farming – like tuna in the Mediterranean – takes young fish which have not yet had time to reproduce,
  - effluents destroy the surrounding natural environments.

- **Non-regulated forest management is on the increase** because of the growth in world demand and illegal felling.

The deforestation of the tropical rainforests (Africa, Asia, South America) **will continue at a rate of 13 million hectares a year, which includes 6 million hectares of primary forest, which is where 50% of the world's flora is to be found.**

2. The pressures of space occupancy

- Space occupancy:
  - ✓ in France, 165 hectares of natural environment are destroyed **every day** to make way for various building projects;
  - ✓ in Brazil, a road **built** through the forest destroys its biodiversity for up to 50 km on either side.

- Mining in biotopes which are rich in biodiversity. **For example, in Guyana, the future area dedicated to the regional natural park** will have 2,500 inhabitants but also **close to 10,000 prospectors illegally panning for gold** (compared to the 1,000 who are declared).

3. The introduction of invasive species

Air and sea travel have now become more commonplace, giving opportunities for the introduction of invasive species.
In France, the number of invasive species increased by 50% in 4 years (102 in 2002; 153 in 2006).

C. And the threat of climate change is looming…

1. The acquired speed

Global warming (+0.7°C) recorded over the last 30 years in Europe has already had consequences:

- on the phenology of species (earlier reproduction, flowering and fruit bearing),
- on the locations of their natural habitat (tropical fish found 1,000 km further North).

2. A very alarming outlook

The IPCC's most recent hypotheses estimate that 35% of the world's species could die out because of climate change.

II. The urgency to take action

In most areas where biodiversity is threatened, **the scientific and technological solutions**

already exist which could reduce the pressures and anticipate the threats.

A. Reduce the pressures

1. The tropical forests

There is an urgent need to protect them as they are both a reserve of biodiversity and one of the biosphere's carbon sinks.

To achieve this protection, conservation measures must be intensified, completed by their generalised rational exploitation to be reintegrated into the global economy.

- ***Conservation***

The creation of forest reserves is an efficient measure but it must be accompanied by:

- grouping these reserves to avoid them returning to a state of isolation. On this subject, the Brazilian authorities must be congratulated for their policy to create 50 million hectares of contiguous forest reserves by 2011;
- creating transit corridors, particularly through the development of agroforestry, in which 500 million people are involved.

- ***Rationalised exploitation***

Outside designated sanctuary areas, **when the rainforest is no longer exploited, it serves no further purpose:** so it is destroyed to pre-finance breeding facilities (Brazil) or industrial plantations (South East Asia or Africa).

The forests must be exploited, but much more rationally:

- only 20% of felled trees are put to use, whereas this percentage could be increased to 40-50%;
- research conducted in Guyana and the Amazonian forest has shown that with exploitation based on more limited felling (5 to 6 trunks measuring more than 50 cm felled per hectare), the entire forest grows back in thirty years – which corresponds to **sustainable exploitation in which the various environments can be reconstructed.**

- ***Reintegration of rationalised forest economics into globalisation.***

  - **Organising certification**

    One of the reasons why the tropical forests are over-exploited is the low cost of most of the species of trees; this is due to **a supply which seems to be unlimited in the short term, even though demand is increasing steadily.**

    Supply must therefore be made "fair", with industrialised countries refusing timber when it does not come from rationalised exploitation.

  - **Including the protection of tropical forests in the Kyoto cycle.**

The anti-deforestation programmes should preferably be financed partially by being included in the carbon dioxide emissions trading market.

2. Fishing

The FAO estimates that **half the existing halieutic stocks are exploited to their maximum** and **that a quarter are over-exploited or completely depleted.**

To protect the remaining stocks, the sustainable management of marine resources must be implemented, implying:

- increasing the creation of marine reserves;
- paying particular attention to the management of coastal environments since 80% of the world's population will be living on a coast by 2050;
- changing to closed circulation aquaculture where the fish will be fed little or no fish meal;
- rethinking fishing governance by basing it on the effectiveness of controls and experimenting with granting individual transferable fishing quotas.

3. Destruction of natural areas

The gradual containment of the destruction of natural areas depends on:

- in France, a reform of the 1976 law setting off the destruction of natural areas by restoring other areas;
- but also the creation of a market to compensate for the harm caused to natural areas, which could be the corollary of the carbon dioxide emissions trading market.

The US already has this kind of market to compensate for the destruction of humid zones.

B. Anticipating the threats

1. The effects of climate change

Because of the impact of global warming, several measures could be taken:

- ***Setting up long term observation structures.***

This could be achieved by developing:

- the initiatives already taken by the ONF – with its system of observation plots,
- the initiatives taken by the IFREMER to observe the ecosystems of coastal waters,
- the European "Lifewatch" project, to study the development of 50 land ecosystems and 50 marine ecosystems from 2014 to 2032.

- ***More systematic predictive modelling of the reactions of the ecosystems.***
- ***Scheduling the creation of animal migration corridors.***

2. The conservation and distribution of seeds

The ONF has a tree gene bank.

France is also participating in a European conservation project of the seeds of the European Union member States.

France should take part in:

- **an initiative of the Royal Botanic Gardens, Kew,** whose objective is to create a seed bank of species from **arid or semi-arid countries** (including Mediterranean species of trees which might be affected by increasing water stress);
- **the Norwegian seed bank in permafrost;**
- **the world seed bank managed by the FAO.**

Finally, **the anomaly** of not allowing the sale of ancient seeds not in the official catalogue **must be eliminated**. A register of these seeds could be created and managed by the French Office of Genetic Resources ("BRG"). The biodiversity protection associations selling these seeds would then no longer be prosecuted.

3. The problem of transgenic organisms and genetic adaptability

The generalisation of genetically modified organisms is an obstacle to maintaining biodiversity.

On the other hand, species are able to develop resistance to drought through the use of transgenic organisms.

A more sophisticated version of traditional genetic selection should be explored. For example, we know that most species of trees have a very high intra-specific genetic variation.

This genetic biodiversity has permitted a **group of conifers in the Orne to withstand the global warming which occurred at the end of the last Ice Age.**

It could be used to combat the effects of climate change.

C. The future competing for space occupancy

a) Fill the tanks?

The current expansion of crops planted for biofuels which have a negative ecological impact is contributing significantly to deforestation in South-East Asia. **It would be advisable to proclaim a moratorium in Europe on the use of these biofuels until the arrival of the second generation.**

b) Feed 9 billion individuals?

How will it be possible to feed 9 billion individuals from agricultural land which is by definition limited and part of which could be threatened by the predicted changes in the hydrosphere?

It is indispensable to undertake the gradual implementation of precision agriculture to optimise natural processes since the techniques of soil forcing and eradication of harmful pests have reached areas of diminishing returns.

The resources dedicated to FAO surveys should be strengthened by closer links with structures like the INRA, the CEMAGREF and the CIRAD, to promote precision agriculture.

III. The sustainable valorisation of biodiversity

The sustainable valorisation of biodiversity is a necessity, **but also an opportunity to be seized.** Biodiversity could be one of the foundations of the change in the way we view economic development – in view of the climate and energy crises.

Two orientations stand out**: payment of the services yielded by the ecosystems and exploring the possibility of a reservoir of products that could be one of the toolboxes of the fourth industrial revolution.**

A. Paying for the services yielded by the ecosystems

1. Many different contributions

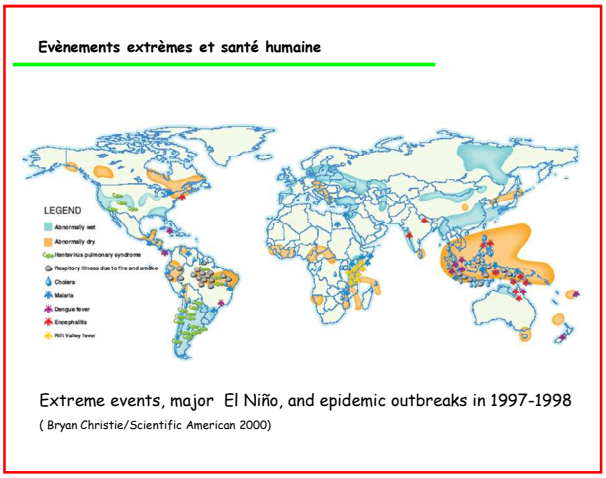
Ecological services can lead to external savings in many areas.

a) Health services

Biodiversity is a major factor in the inhibition of many diseases (leishmaniose, Chagas disease, Lyme disease, etc.).

Climate change emphasises the importance of this inhibition, which is assured by the biodiversity of the ecosystems:

- the upwelling of **El Niño** produces **a rise in epidemics** in the Southern hemisphere**;**



Extreme events, major El Niño, and epidemic outbreaks in 1997-1998
(Bryan Christie/Scientific American 2000)

- yet **there are three hundred times as many agents that are pathogenic for mankind in the tropical zones** than in the temperate zones; under the impact of global warming, some of them could migrate (as shown by the recent propagation of blue tongue disease or chikungunya on the Mediterranean coastline).

b) Agronomic services

In addition to pollination, biodiversity is a source of key agronomic services.

- ***The increase in the produced biomass***

  Research conducted in Europe and the United States on green plants has revealed a **positive correlation between the variety of species planted and the biomass harvested per hectare.** The INRA has conducted identical research on cereals with the same results.

- ***Resistance to drought***

  Experiments of the same kind conducted in the United States and Burkina Faso have shown that greater biodiversity produces a better resistance to drought.

- ***Resistance to harmful pests***

  The INRA studies have shown that introducing deciduous trees into industrial plantations of conifers reduces the impact of harmful pests, as can be the planting of hedges.

c) Hydrological services

Humid zones – half of which have disappeared in France over the last fifty years **– forests and embankments play a vital role in hydrological distribution.** Principally with respect to two points, filtering the water and the cycle of the slow retention-elimination of water**.**

Humid zones have a valuable capacity to eliminate the nitrogen in nitrates coming from the catchment areas.

Another example, the humid zone of La Bassée upstream from Paris plays an important role in regulating the waters, removing the necessity to construct storage dams (saving an estimated 200 million euros).

2. Services to be reintegrated into the economic calculation.

a) The facts of the problem

The goods and services yielded by biodiversity were gauged to be **about 33,000 billion dollars in 1977, i.e. a figure similar to that of today's world gross domestic product (some 35,000 billion dollars).**

The ecological services therefore provide us with a free second world gross domestic product.

b) The search for integration solutions

Ecological services should be paid and their destruction for private ends penalised economically.

The means of this integration exist:

- **at French level,** the creation **of a market to compensate for destruction of natural areas,** based on the compulsory allocation of "biodiversity units" which can be traded. This market could be implemented by gradually introducing the polluter/payer principle and be supplemented by specific actions to pay for the hydrological services yielded by natural areas (humid zones, forests, hedged farmlands);
- **at European level,** the strengthening of the agro-environmental measures of the second pillar of the common agricultural policy (currently only 10% of its amount) which will be made possible by the increased prices of agricultural raw materials. **This initiative must be founded on the search for a new social contract with agriculture.**

B. One of the toolboxes of the new industrial revolution

1. Biomimetism and bioinspiration

Many industrial processes we use are wasteful in energy, costly in fossil raw materials and insufficiently selective.

Compared to human artefacts, evolution has produced far more sophisticated natural solutions.

a) Biomimetism

The aim of this approach is to:

- ✓ identify an interesting pattern of behaviour,
- ✓ understand the behaviour-structure relationship,
- ✓ imitate the structure to make durable materials rapidly at a low cost.

The application of this biomimetism approach has already led to the production of some concrete industrial examples:

- ✓ phototonic crystals made of latex, used to vary the optical effects of materials,
- ✓ rain-repellent windscreens which imitate the structure of the water-lily leaf,
- ✓ optimisation of the geometry of wheels inspired by the geometry of ammonites,
- ✓ creation of aerofoils from observing birds' wings, etc.

b) Bioinspiration

Bioinspiration, which is at a less industrially advanced stage, will try to identify molecules with certain properties and make products from them differing from those created by the living organisms.

2. The living organism factory

a) The bacterial world

The bacterial world remains one of the least known areas of biodiversity.

It is estimated that there are between 600,000 and 6 million bacterial species whereas just 7,300 have been identified.

They have certain very interesting specific characteristics in terms of their ability to adapt:

- speed of reproduction,
- presence of genomic transfer islands (by incorporating the genome of other bacteria as a result of selection pressures),
- existence in extreme environments (high and low temperatures, high carbon dioxide levels, in salt or acid).

This biodiversity should be valorised to **obtain products differing from those yielded by it.**

b) The valorisation of bacterial biodiversity

The industrial use of bacteria as a substitute or a support for the chemical industry opens new horizons.

Compared to the chemical industry, **biotechnologies** offer several advantages:

- ⇨ they are **far less energy-consuming** since they do not require any thermal treatment and use renewable materials,
- ⇨ they are **much more accurate**:
  - ✓ *regioselectivity* (the enzymes can act on just one alcohol of a sugar to be transformed),
  - ✓ *directivity* (the enzymes will only generate a single product whereas chemicals will generate more or less collateral waste depending on the case).

Therefore **bacteria can be used for direct production (ex: penicillin), or by extracting enzymes to make bioconversions to have them accomplish a stage in a chemical process.**

The industrial examples of these uses are numerous: manufacture of tergal, depollution, manufacture of beta-carotene, manufacture of methane, corticosteroids, etc.).

The generalisation of these uses will in the coming decades be one of the levers for the modulation of our development towards more sustainable processes.

3. Bioprospecting

The identification of active molecules coming from living organisms is fertile ground for pharmacology where it is already used (taxol from yew trees, the Madagascar periwinkle, etc.).

TEN PROPOSALS TO DO MORE THAN THE GRENELLE ENVIRONMENT FORUM

I. Integrate biodiversity into globalisation by:

- *creating a United Nations body specifically dedicated to world environmental issues;*
- *implementing the protection of the tropical forests by including it in the Kyoto II mechanisms;*
- *introducing a tax on the international trade of non-certified produce (fishing, forestry);*
- *integrating the environment dimension into the WTO rules;*
- *and increasing the debt/nature exchanges.*

II. Give effect to the European Union's efforts by:

- *proclaiming a moratorium on the first generation biofuels;*
- *strengthening the environmental pillar of the common agricultural policy;*
- *increasing the research effort into climate change;*
- *creating a European label for produce deriving from biodiversity;*
- *and engaging a reform of the European fishing policy.*

III. Put France's words into practice by:

- *a more careful management of France's marine biodiversity;*
- *enacting the international agreements signed by our country;*
- ***and supporting our seed bank and seed development system.***

IV. Declare biodiversity to be a research priority by:

- ***implementing control technologies to protect biodiversity;***
- ***and valorising the scientific stakes of biodiversity (development of research into ecological engineering, consolidation of research into biomimetism and bio-inspiration, creation of an "Institut Carnot" for industrial biotechnologies).***

V. Adapt the fiscal tool to the environmental stakes and appoint a member of parliament with the mission of proposing an adaptation of the tax laws by:

- ***reducing the fiscal pressure on natural environments;***
- ***reviewing the fiscal incentives for the artificialisation of natural environments;***
- ***and modulating the subsidies of local authorities in a direction that is favourable to maintaining biodiversity.***

VI. Integrate the services yielded by ecosystems into the economic calculation by:

- ***paying for ecological services, in exchange for the gradual introduction of the polluter-payer principle,***
- ***and creating a market to compensate for the effects on natural areas which could be the corollary of the carbon dioxide emissions trading market.***

VII. Undertake sustainable territorial development by:

- ***passing legislation to introduce the "green thread" anticipated by the Grenelle environment forum,***
- ***and imposing eco-conditionality in any operation impacting territorial development.***

VIII. Launch a programme of urban densification.

IX. Anticipate climate changes by:

- *appointing a Member of Parliament for climate change attached to the Minister of the Environment,*
- *using predictive modelling to measure the evolution of ecosystems,*
- *scheduling the creation of animal migration corridors,*
- *and setting up a structure to identify and quickly eradicate invasive species.*

X. Define a new social contract with farmers by:

- *having the INRA and the CEMAGREF undertake a mission to implement the introduction of high precision agriculture which will be less harmful for the ecosystems and more productive,*
- *and giving farmers a new role in the protection of biodiversity by rethinking the second pillar of the common agricultural policy.*