

# Taking into account the dynamics of adaptation for better management of uncertainty: the importance of forest genetic resources

by François LEFÈVRE

Beyond the individual capacity of each living organism to deal with changes in its physical environment, there also exist within natural and man-induced ecosystems multiple biological interactions between such organisms which will also be affected by climate change. Furthermore, climate change has an interactive relationship to changes in customary land use, local and regional land development and the evolution in the regulatory framework. The scale of short-term global change (particularly for trees) amounts to a new context whose impact is manifest in the symptoms already visible in forests and woodlands: modifications to growth and productivity, sporadic or massive deterioration, an evolution of wildfire in certain areas, insect migration, displacement of species' distribution areas, biological invasions...

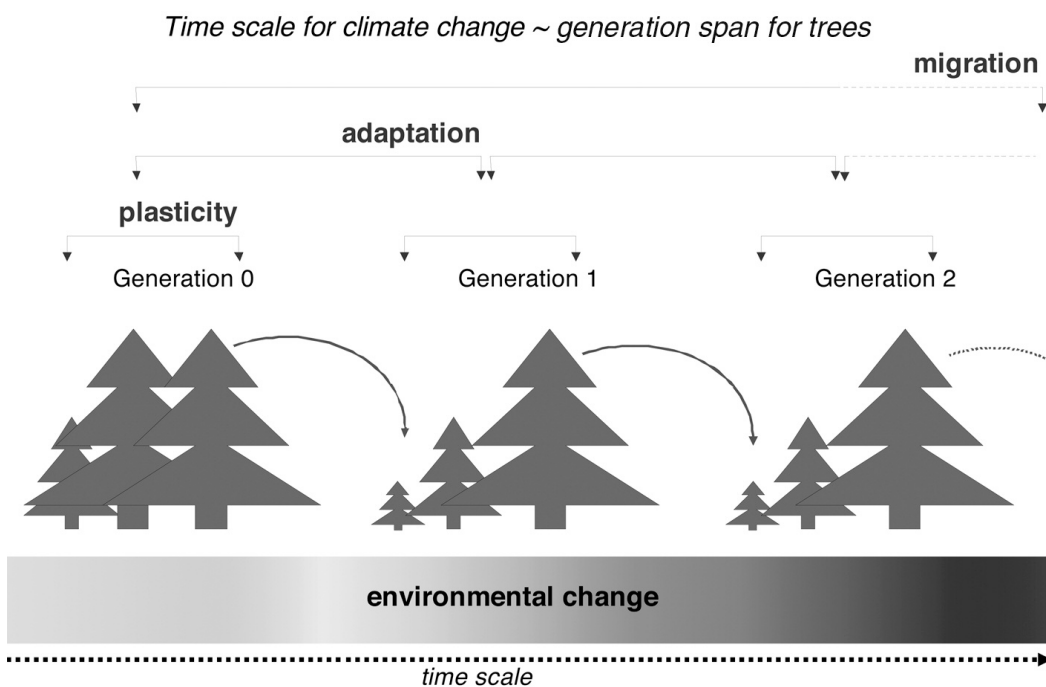
The sure fact that major changes are under way goes hand-in-hand with our uncertainty about a number of issues: doubts about the socio-economic scenarios that arise from the interaction between localised and global processes; or about scenarios where climate is seen from an overall perspective but also, indeed especially, in terms of the frequency and severity of damaging events; uncertainty about the ability of organisms to respond biologically to alterations in their physical environment, or about the ecological response of complex ecosystems

whose constituents do not react to change with the same ability nor at the same speed; and doubts about the indirect impact of the measures for adaptation that we undertake, particularly the most innovative of them.

The forestry sector was quick to take into account this new, unprecedented situation (see references below). This is not surprising, as the time frame for such change is the same as that needed for ecosystems to react or respond to management methods: in the course of the 20<sup>th</sup> century, the rise in France's average temperature was 1°C and could well be greater in the coming century. A century is also the time span for one tree generation or two, depending on the species, or four or five forestry rotations, depending on the type of stand. The principle of precaution should definitely not be seen as support for the side denying climate change or refusing to react. On the other hand, it does not favour doing just any new thing since unsuitable adaptive measures, by their indirect impact, are likely to accelerate changes and intensify their effects. The challenge, then, is to act now despite our uncertainty, striving all the time to resolve our doubts and continually improve our strategies. A forest's genetic resources can contribute to meeting this challenge.

By the term genetic resources is meant plant material (whole populations, individ-

ual specimens) whose genetic diversity represents effective or potential value. Genetic resources are not like mining deposits: first of all, each entity harbours within itself great diversity (for each forest species, the genetic diversity throughout a population is greater than the divergence between populations) and secondly, the resources are living elements that possess their own evolving dynamic. In this light, the different criteria for assessing genetic resources can be defined: their nature, in terms of response to objectives (ecological or economic) fixed at a particular time; their adaptation, which means the ability to survive, grow and reproduce in fixed environmental conditions; and their adaptability also, which means their capacity to evolve in a changing environment (flexibility of trees presently growing or genetic evolution over generations). While genetic resources are not a rigidly-fixed substrate, this fact does not merely bring additional complexity: their evolutionary nature is a real trump card in responding to the context of change with all its inherent uncertainty. Hence, this capacity of genetic resources to evolve is fundamental and it stems from their genetic diversity. So the challenge is to meet a two-fold objective: preserving genetic diversity over the long term, which is essential for keeping future options open, and at the same time favouring evolutionary processes to accelerate present-day



**Figure 1:**  
Time scale for climate change and generation span for trees

François LEFEVRE  
Institut National de la  
Recherche  
Agronomique (INRA)  
UR 629 Ecologie  
des Forêts  
Méditerranéennes  
Site Agroparc,  
84914 Avignon  
Cedex 9  
Email : lefevre@  
avignon.inra.fr

adaptation of resources to their changing environment.

This two-fold objective, fostering adaptation while preserving biodiversity, necessitates developing a dynamic approach to diversity. This involves focusing more on evolutionary pathways than on any actual state. That is to say: in such an uncertain context, how can one's goal be to define in advance, once and for all, an ideal state for the medium or long term without risking a mistake in understanding future needs when the risks of the indirect effects of the chosen option are not taken into account? A strategy based on evolving pathways, with the above-defined twin objectives, keeps the options open for continuous adjustments (adaptable strategy). Such a strategy must rely on our understanding of the dynamics of evolutionary genetic processes and it should also integrate as fast as possible new knowledge in this area in a combined research-action spearhead by which research, collective expertise and transfer of knowledge are effectively coordinated.

On the time scale that concerns us here, the genetic diversity of a population evolves via different processes: stochastic (random effects of sampling in a finite population), directed (natural selection by the physical habitat and biotic interaction), and the flux of genes (exchange of pollen or seeds). It is clearly apparent that such processes are influenced by silviculture through the number of reproducing individuals, duration of the reproduction process, selection of the types of specimen contributing to the following generation, intensity of competition, level of other forms of selective pressures, planting of selected material... But evolutionary processes are impacted first by land use and development, which determine the degree of the flux of genes and the migration of species, and also, at another level, by directives and regulations which will have governed the preceding action (see Fig. 1). Thus, every stakeholder in this economic sector should feel involved in the strategy for the sustainable management of forest genetic resources.

For people at a local level, the tricky question is the time frame for anticipating. There exists a very wide spectrum of forestry policies. These range from the maintenance of existing species by going in the direction of their innate ability to evolve genetically, to a

drastic mutation of populations by the introduction of exotic species; or intermediate strategies yet to be designed, akin to "genetic reinforcement" of local populations. At what point does one decide that a given option can no longer be envisaged? The problem can be tackled in terms of costs-benefits-risks associated to various management strategies on the basis of our understanding of evolutionary processes. It goes without saying that such a reasoned approach will evolve as our knowledge increases. The Commission on Forest Genetic Resources has taken this approach (cf. brochure mentioned above).

In conclusion, forest genetic resources are one of the elements on which adapting forests to climate change should be based. This aspect should be better taken into account as of now by all those involved in the sector. Given the prevailing uncertainties, adaptable strategies must be adopted and apparently miraculous solutions eschewed. In terms of genetic resources, this is possible if a two-fold objective remains the guideline: preserving genetic diversity over the long term while at the same time favouring evolutionary processes to accelerate present-day adaptation of resources to their changing environment.

F.L.

### Bibliographic references

- Legay M. & Mortier F. (2006) La forêt face au changement climatique, adapter la gestion forestière. *Les Dossiers Forestiers de l'ONF* n°16
- ONF (2007) Forêts et milieux naturels face au changement climatique. *Rendez-Vous techniques de l'ONF*, hors-série n°3
- Roman-Amat B (2007) Préparer les forêts françaises au changement climatique. Rapport à MM les ministres de l'Agriculture et de la Pêche et de l'Ecologie, du Développement et de l'Aménagement Durable
- Forêt Méditerranéenne* (2008) Actes du colloque changements climatiques et forêt méditerranéenne Nov. 2007. Tome XXIX n°2

1 - For more information, a document (4 pages), written by the Commission on Forest Genetic Resources « *Preservation and use of the diversity of forest genetic resources to strengthen the adaptability of forests to climate change* » is available in the website <http://agriculture.gouv.fr/conservation-des-ressources>