Lessons from hundred years of international research in forest genetics and breeding

Csaba Matyas[1]

Introduction

There are few areas of science - probably with the exception of nuclear physics - that underwent in this century a similarly rapid expansion as genetics and provoke comparably ambivalent and emotional reactions.

Applied genetics and breeding became increasingly an integral part of forest research and extension; after a "heroic period" following the second World War, progress in this field accelerated in the last two decades when molecular methods became widely accessible for forest genetic research. What did silviculture benefit from the century of genetics? It is a strange development that while modern genetics offers an unprecedented wealth of new insights and of subtle analysis methods applicable in forest tree breeding, the acceptance of any interference in natural genetic processes and the plantation management of improved forest trees is being increasingly criticized both in the public and in professional circles.

It appears that the main attention of present-day forest genetics is focused on the support of close-to-nature management. However, considering the global state of forest resources, it seems at least doubtful that forest genetics could be restricted to basic research and conservation issues. There are at least four very serious challenges to mankind, which are related to forestry in general and – directly or indirectly - also to forest genetics, and demand active involvement:

- catastrophic depletion of forest resources (including genetic resources) and the degradation of forest sites, hand in hand with population increase in the developing world;
- acute shortage of firewood in the arid and semiarid tropics, the energy crisis of under-developed regions;
- environmental threats to forests in industrialized regions; and
- impending effects of predicted climatic changes.

All the four are of global character and forest genetics and breeding cannot ignore these problems. Besides the surveying and analysis of processes in natural populations, the research in possibilities of increasing yields and the improvement of adaptability and resistance through breeding cannot be neglected. The rapid transfer of applicable knowledge to regions where it is needed most should be encouraged therefore by all possible means.

1. A century of international cooperation: the beginnings

Although documented initiatives to investigate the heritable variability of traits in forest tree species have a long history and can be traced back into the 18th century, the birth of forest tree genetics as an international research field can be dated to an event exactly a century ago.

During the meeting of the newly founded International Union of Forest Research Institutions (IUFRO) held in September 1900 in Zurich, Switzerland, Prof. Mayr from the Bavarian Forest Research Institute (Munich) proposed the initiation of „international comparative trials (later called provenance trials) to elucidate the effect of the seed provenance". The proposal was based on results published by the Austrian scientist A. Cieslar on experiences with conifer plants from various altitudes grown in common garden tests. Prof. Mayr wrote...” these experiments touch a very important aspect of plant biology and agronomy. The question of the heredity of growth potential is tightly linked to other problems, such as... the questions of adjustment to climate extremes, of acclimation to conditions outside the natural distribution; how much of this adaptation, if existing at all, can be transferred to the progeny?”

These are remarkably modern thoughts, considering the fact that this was the year of the rediscovery of Gregor Mendel’s laws of heredity, and it took still another decade before Morgan identified the chromosomes as the site of the hereditary material.

A direct consequence of the 1900 resolution to initiate internationally coordinated experiments in forest genetics, was the start of IUFRO provenance tests in 1904 and 1905 with larch, Norway spruce and Scots pine. Many more followed and created an innovative basis for transboundary cooperation and for the present-day research groups linking continents. Although considered by many as outdated and old-fashioned compared to the elegance and sophistication of molecular methods, I believe that these international experimental series are among the most important achievements forestry may offer to biological sciences. Apart from their original aim to identify best-adapted sources for planting, the growth and survival of these unselected, wild populations offers many conclusions and insights into quantitative aspects of genetic variation and of adaptive response. These possibilities are by far not fully utilized yet in forest genetics and are barely appreciated in biology or ecology.

2. Looking ahead: a World Consultation in China

In the 1960s and 1970s, three World Consultations on Forest Genetics and Tree Breeding have been organized in Stockholm (1963), in Washington (1969) and in Canberra (1977). The locations of the conferences indicate that in the booming phase forest genetics and tree breeding was an issue predominantly pursued by developed nations. Although numerous thematic and regional meetings have been held since then, in the last two decades no conference was organized with a comparable global scope.

At the doorstep of a new millennium, and preparing for the first IUFRO World Conference of the 21st century in Kuala Lumpur, Malaysia, it seemed appropriate for IUFRO's thematic divisions to review achievements, mark out the state of progress in their scientific areas and identify future tasks and needs. Leading scientists of IUFRO's Division 2, "Physiology and Genetics" decided to organize an all-division conference on forest genetics and tree improvement in 1998 in China. The author accepted the task of designing the concept and scientific program of the conference, while Prof. Hong Jusheng (Chinese Academy of Forestry, Beijing) initiated the local conference organization.

The aims of the conference were to present and discuss accomplishments, current trends and expected future developments, to redefine the role of forest genetics and breeding in contemporary forestry, to set priorities for future research and development, and to present a comprehensive diagnosis of the situation of forest genetics and tree breeding research, identifying main problems and offering solutions. The meeting was organized in a consultative, interactive manner. Key speakers of world reputation introduced thematic areas, followed by discussions, aiming at the formulation of concrete recommendations. The chapters in this volume have been prepared on the basis of the invited lectures presented there.

There were many reasons to organize the fourth Consultation on Forest Genetics and Tree Breeding in Beijing. Bringing this conference to China emphasizes the fact that the majority of the world's population still has wood and timber in short supply. In view of the ongoing depletion of forest resources, forest geneticists have to offer their expertise to help to solve this problem in a sustained manner. In this field, the developed countries have accumulated a great deal of knowledge that needs to be shared with the rest of the world. Among politicians and decision-makers of many parts of the world it is still not sufficiently understood that sustainability of forests cannot be achieved without taking into account the results in the field of genetics.

China is a positive example for a country where these tasks have been taken seriously. Information on afforestation and rural tree planting indicates that the importance of forests and trees for the demands of a rural society is well understood. The application of tree breeding and genetics in these programs seems natural and inevitable, giving evidence of the profound social and economic dimension of this rather theoretically looking discipline. These developments are documented in detail in the chapter on China in this volume.

3. Looking back for lessons

After a period of surveying the potential in forest genetics up to the 1950s, postwar economic expansion triggered an unforeseen boom in tree breeding projects in the developed world, fueled by a firm belief in unlimited growth. The high expectations were only partially fulfilled with the advent of new ideas on nature (biodiversity) conservation and sustainable development about three decades later. The re-thinking of aims and perspectives in the mid-1980s coincided with the appearance of new molecular methods in forest genetics. The last 15 years brought an unparalleled expansion in knowledge, and fundamental forest genetics research became probably the fastest-growing discipline serving silviculture. This offered excellent conditions for the support of tree breeding programs. Instead, beginning in the 1980s an increasing shift of research emphasis occurred in the developed world toward molecular genetics and conservation. At the same time, the public support for tree breeding programs has been fading. The reasons and consequences of this shift are extensively dealt with in other papers of this volume.

As a result of this change in research emphasis, much of present-day forest genetics research is serving first of all the understanding of natural processes, the preservation and restoration of natural forest ecosystems, and the development of close-to-nature forestry. The goal of breeding trees to increase timber yield, or producing improved planting stock for man-made forests has earned in the recent years a dubious reputation both in professional circles and in public opinion - at least in the developed world. The yield of forests set aside for nature conservation purposes in the Northern Hemisphere is probably comparable to the potential of tree breeding in that region.

<u>Need for public acceptance and long-term thinking</u>

The long life cycle of trees facilitates the drawing of some conclusions from the past hundred years of forest genetics and tree breeding. One lesson of the ups and downs in forest genetics may be summarized as „trees live longer than research concepts" (D. Lindgren, pers. comm.). The difficulties with frequent changes in priorities and policy affects all disciplines, but forestry suffers more due to the long time period involved. Among specific problems of forest genetic research, the lack of long-term commitment is certainly the most critical; the scientist community is obviously unable to influence decision-makers and society to make this claim understood.

Inadequate support, even among professional foresters, is partly due to the esoteric nature of genetic research. Although it seems unlikely that substantial changes can be achieved in the short term, elements of long-term thinking have to be strengthened both in research funding policy and in public acceptance. *The emphasis should be not only on the sustainability of forest resources: forest genetic research must equally be sustainable!* To achieve this, forest geneticists and breeders have to develop a greater sensitivity towards political and social processes in the modern society. Support may be expected only if it can be unquestionably proven that forest genetics and breeding can be integrated in the concept of sustainable development, without presenting any threat to the diversity and stability of natural forest ecosystems. Forest genetics has the unique tools to prove this, if only the proper ways and means can be found to convey the message to professional decision-makers and the public. Public media should be utilized to a larger extent and interdisciplinary encounters should be sought with other branches of sciences, including the social sciences.

Need for practical links

These messages should be very clear, simple and understandable to be heard in a world overloaded with information. This applies also to the communication with the potential users, namely forest owners and managers. The dependence of research on short-term project funds often isolates it from practical approaches and isolates forest genetic research from the users. Additional funding from the forestry sector – even if generating further administrative problems and distracting energies from programmed work – helps to build a longer-term user commitment and the orientation of research objectives. Just as adaptive changes in tree populations serve the maintenance of species identity, the scientific community has to constantly check actual trends to adjust priorities and aims.

Decisive trends of the present are the maintenance of biological diversity and conservation of genetic resources. There is still not enough awareness in ecology that genetic diversity is the basic element of diversity and a precondition of the stability of forest ecosystems.

International agreements and initiatives may provide support. Funding agencies accept recommendations and proposals easier if formulated by quasi-neutral international bodies or organizations. International networking of research may not only help to find useful collaboration but also sensible sharing of costs as well as additional funding.

Need for a synthesis

The wealth of results and information in contemporary genetics is so large that it is hardly comprehensible to outsiders. It becomes increasingly difficult to understand or decide what is the value of the new information for the practice, how relevant and valid a research finding is. The temptation is great to look ever deeper into details of the hereditary material instead of trying to reach a synthesis. In order to maintain the clarity of purpose of forest genetics research, it is absolutely necessary to be able to identify really important research areas and knowledge gaps. This clarity has increasingly become necessary to justify the financing of further research. The pressing need for synthesis is most evident in the knowledge gap between the results of molecular genetics research and the expression of quantitative traits of adaptive significance.

Need for field experimentation

Doing research with trees means dealing with long-living organisms. In spite of all difficulties, long-term observations in field experiments are indispensable and cannot be replaced by shortcut methods. These experiments will be limited in number by financial and other constraints. It cannot be guaranteed that even the most carefully selected research concept will be valid for the whole life of a long-term field test. But if the design is sound, the documentation as complete as possible and the demarcation in the field well maintained, such tests will prove to be extremely valuable sources of information that cannot be modeled by computer or simulated in growth chambers. Not even the most sophisticated program can fill in the complexity of “real life”. The problem of laboratory and modeling work is certainly not the lack of precision; rather it is the magnitude of the investigated effect in a synergistic system of interactions, which can only be assessed under natural growing conditions. This is so even if a large part of such tests is lost or damaged due to a diversity of natural and man-caused impacts.

Need for an ethical approach – the responsibility of the international scientific community

The current practice of research funding and of excellence assessment does not necessarily exclude elements of counterproductivity. With the increasing complexity of science, there are fewer and fewer experts with both an in-depth understanding of specialized areas of research and the connections between them. It is the responsibility of the international scientific community to act as a guiding force to promote creative and synthetic research and to discourage proliferation of repetitive and confirmative work.

It lies in the nature of the investigated subject that securing the continuity of basic concepts has also ethical aspects. Looking back on past achievements helps to understand present trends and to remain humble with expectations, promises and forecasts.

New ethical problems are emerging in connection with the advent of genetic engineering in forestry. It has to be conceded that not even the relatively simple control of traditional forest reproductive material trade is followed to a satisfactory level. A similar statement can be made about the general state of conservation and utilization of genetic resources (see for details in the respective chapter of this volume). One may be justified in doubting that regulations governing the introduction of genetically modified organisms alone can effectively withstand pressure from commercial interests. Again, only the scientific community has the expertise necessary to provide objective information for decision-making. Scientific judgement will only be respected if the public can be convinced about the ethically acceptable and sound guiding principles of forest genetics. To maintain and strengthen this approach is a basic task of the scientist community. Its importance cannot be overestimated.

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