

7 Recommendations for riparian ecosystem management based on the general frame defined in EUFORGEN and results from EUROPOP

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Introduction

Resolutions H1 and H2 from the Ministerial Conference of Helsinki (1993) led the European countries to build up and implement a concerted program for the preservation of forest genetic resources in Europe, EUFORGEN, aiming at the coordination and harmonisation of national activities (Turok *et al.* 1998¹). One of the recent tasks of the *Populus nigra* Network, within EUFORGEN, was to initiate *in situ* conservation for this species. The challenge, in that case, is to monitor the genetic resources of a pioneer species in a dynamic ecosystem. A technical bulletin is published by this group to set up a general frame for *in situ* conservation activities (Lefèvre *et al.* 2001). The following topics are addressed: types of conservation units, the interaction between ecosystem' dynamic and poplar biology, guidelines for restoration projects, criteria and indicators to monitor the genetic diversity. In order to go one step further, from this general frame to the implementation of conservation activities, one expectation for the EUROPOP research project was to provide scientific information on the processes of evolution of poplar genetic resources which could be turned into practical recommendations. In these pages, we tried to initiate such a procedure on the basis of the preliminary results that are available at that time.

As a general objective, the conservation of genetic resources should preserve the potential for future adaptations of species and populations in the long term, allowing for evolutions with special attention to changes in the environment, e.g. climate change/global warming. From this general statement, three operational objectives can be derived for *in situ* conservation strategy:

1. ensure optimal quantity of regeneration;
2. prevent loss of genetic diversity and loss of individuals' fitness at generation turn-over;
3. identify and preserve local or regional gene pools, if existing.

From our research on life history traits within the EUROPOP project, we were able to draw conclusions about ongoing processes of evolution such as gene flow (seed & pollen), mating system, clonal propagation, introgression. However, since our studies were merely based on different kinds of genetic markers (isozymes, nuclear SSR, cpDNA markers, and leaf morphology), no information is available on processes related to local adaptation.

¹ see also the web pages www.mmm.fi/english/forestry/policy/minkonf/document_main.htm and www.minconf-forests.net/Basic/FS-MCPFE-Resolution.html

On the basis of our results recommendations can be made for managers in charge of the maintenance of the genetic diversity. Our approach has been to use the new results to make recommendations to a range of questions which we pose from a conservation and management perspective. These recommendations always refer to the three stated objectives. Basic results are presented in detail in the various papers of this volume. This paper is an attempt to turn scientific results into practical recommendations. It is not supposed to be an exhaustive list of questions and recommendations either.

As a future work, there is a need to look at adaptive variation both across Europe and at a much more local level so that we can make recommendations about transfer of genepools in particular for restoration projects where the local resource is scarce: should such transfer be avoided or promoted?

Question 1: Choice of conservation sites

The problem

In situ conservation is generally based on a network of conservation units. Many questions relate to the number and geographic distribution of conservation units that should be considered. Although we did not address specifically the topic of local adaptation, our results can be used to give some answers.

EUROPOP results

- there is a significant genetic differentiation among populations within each country;
- even populations within a river-system may be differentiated one from each other;
- the amount of diversity is variable among populations;
- there is no accumulation of diversity downstream in the rivers;
- the amount of clonal redundancy is variable from one population to another.

Recommendations

1. the conservation units should be distributed over the range of the species, not only at the European level, but also within each country. The choice of locations can be based on two criteria: ecological parameters (latitude, altitude, climate) as indicators of possible local adaptations, and the map of cpDNA lineages as an indicator of post-glacial re-colonisation routes from distinct gene pools. The second criteria is purely prospective since we have no evidence that cpDNA lineages effectively structure the diversity for adaptive traits, however, we can assume that some original genes might be maintained in different lineages.
2. ideally more than 1 conservation site per river-system is needed. For example the conservation units along the Rhine in Germany do not decrease the need for conservation units along the Rhine in the Netherlands.
3. a preliminary estimate of the genetic diversity among adult trees in the candidate populations is recommended: the objective is to have the maximum diversity and the lowest number of clonal duplicates in the reproductive generation.

Question 2: Gene flow from cultivated varieties

The problem

This is a complex problem and a more detailed synthesis is being prepared (Vanden Broeck *et al.*, *in prep*). We only refer here to the three initial objectives, from a biological perspective. Two different processes are included here: (i) true introgression of genes from different exotic species, mainly with *P. deltoides* and *P. trichocarpa*, through gene flow with cultivated hybrid poplars, and (ii) gene flow with *P. nigra* with cultivars such as ‘italica’ or ‘thevestina’.

From a biological point of view, gene flow from a diverse source has a balanced impact with both positive and negative effects: it may increase the genetic diversity (positive), it may alter local adaptation (negative). Individuals’ fitness may be affected by such gene flow. The question then is about the mean fitness of the population after natural selection. We refer in that case to objectives #2 and #3 that were initially stated.

Another possible impact of intensive gene flow with cultivated varieties is a reduction of effective population size leading to a loss of diversity and an increase of the level of inbreeding (referring to objective #2). This may occur when, for example, a single male variety (single clone locally?) pollinates intensively a majority of female trees.

EUROPOP results

- *P. deltoides* genes are sometimes detected at the seedling stage. There is a large difference in introgression levels depending on the presence of competing *P. nigra* males. Introgression is more frequent when the *P. nigra* female is an isolated tree.
- older introgressed individuals are rare over Europe
- *P. trichocarpa* genes can also introgress *P. nigra*
- *P. nigra* ‘italica’ cannot hybridise with the local resource in Northern Europe due to non-synchrony of flowering, but it may do so in other regions. Gene flow from *P. nigra* ‘thevestina’ could be detected.

Recommendations

1. ideally, conservation units should be more or less isolated from poplar plantations. However, there is no need to have a total ban on all poplar plantations around the conservation units provided the population size of the conservation unit is sufficiently large. For restored populations, isolation can be achieved through a “buffer zone” around the population made of local male and female trees.
2. there should be a strategy to monitor the amount of introgression in the conservation unit so that levels of introgression can be assessed in the current adult trees compared with that occurring in the next generation when it reaches the flowering age. When detected within the conservation unit, adult hybrids should be removed.
3. the rate of introgression from *P. trichocarpa* should be further checked, particularly in the regions where interamerican hybrids are present in large numbers.
4. concern regarding the potential of *P. nigra* cultivars to act as super-pollinator clones or super seed clones relates to local flowering phenology of such varieties compared to the wild resource, and even there only when the number of local adult trees is limited.

Question 3: Population size

The problem

Population size should be large enough to avoid the effect of drift (random loss of genetic variants due to stochastic processes) on the genetic diversity and on the level of inbreeding. A small population will have a high degree of allele fixation in future generations. Moreover, since poplar is an allogamous species for which an important genetic load is expected, the impact of inbreeding on the mean fitness of the population may be important (see objective #2). Therefore attention should be given to the “inbreeding effective population size”: this is maximised when the largest number of male and female trees mate in a balanced mating system. Gene flow is also a factor that can enlarge population size.

EUROPOP results

- mating does not occur at random and a female tree preferentially mates with a restricted number of males (this may be due to factors such as distance and phenology, but may also be due to genetic factors)
- half-sib progenies from a single mother tree involve only few pollinators
- gene flow follow the model of isolation by distance
- effective gene flow differs from potential gene flow and seedling establishment is probably a limiting factor
- gene flow is not uni-directional, which means that the main factor of dispersal for pollen and seeds is the wind

Recommendations

1. attention should be given to the effective number of male and female trees which effectively contribute to the next generation. For a given number of male trees, probably some of them will be more successful for pollination leading to unbalanced effective sex ratio; therefore an extra number of males can be needed. From another point of view, the number and spatial distribution of female trees is also critical since it also determines part of the mating success of each male tree.
2. conditions for seed-set (light) and seedling establishment (bare soil, water table) should be optimised
3. restoration of populations should be practised using unrelated clones rather than seed progenies. Especially “seed orchards” are not a good solution for that particular species since they may magnify the effect of preferential mating, especially when the number of genotypes is low.
4. to assist regeneration whenever needed, several scattered seedling patches are probably more efficient than a single large one
5. small conservation units used as “bridges” between larger populations should be less than 5 km apart so they can contribute significantly to the population size.

Question 4: Choice of indicators for the monitoring of local evolution

The problem

Managers in charge of gene resource conservation should monitor the evolutionary processes in the conservation network. The technical bulletin from EUFORGEN proposed a set of indicators based on ecological observations (at the ecosystem level), on demographic parameters (at the population level) and on genetic parameters (at the individual level). Each indicator provides information about one or several processes. Our results should help to identify the key processes that should be monitored.

EUROPOP results

- genetic drift effects were detected at local scale (within stand) from the differentiation among cohorts. From the theory we suspect that it can affect the fitness of the populations through an increase of the level of inbreeding.

Recommendations

1. particular attention must be paid to all practices that have an impact on the flowering habit and the regeneration process, which determine the effective population size.
2. the most relevant ecological and demographic indicators are: the hydroperiod (which provides information about the dynamics of the ecosystem and therefore the potential for regeneration, but maybe also the rate of clonal duplication), and the structure of habitats (which is directly related to the demographic structure), the number and distribution of male and female trees (which is directly related to population size). Another demographic indicator would be the distribution of age classes: in the older populations, each tree had more chance to effectively contribute to the regeneration through time than in a recent population.
3. A possible genetic indicator would be the heterozygosity of the seedling generation, using some of the markers that were developed during this project (which provides information on drift, mating system and selection).

References

- Lefèvre, F., N. Barsoum, B. Heinze, D. Kajba, P. Rotach, S. de Vries, Turok, J. (2001) Technical Bulletin on *in situ* Conservation of *Populus nigra*. International Plant Genetic Resources Institute, Rome, Italy (in press).
- Turok, J., C. Palmberg-Lerche, T. Skroppa, Ouédraogo, A.S. (1998) Conservation of Forest Genetic Resources in Europe. In : Proceedings of the European Forest Genetic Resources Workshop, 21 Nov. 1995, Sopron, Hungary. Rome : IPGRI, 60 p.