How to get students to conserve plant diversity? The benefits of a new approach to the relationship between scientists and society.

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Abstract

Conserving biodiversity with efficiency needs the participation of citizens. So the fourth mission of the Conservatoire Botanique National du Bassin Parisien is to promote education in the framework of biodiversity conservation programmes. Since 1995, the Conservatoire has been studying the decline of a glacial relict in the Fontainebleau forest, near Paris. We conducted *in situ* experiments to evaluate the benefit of bringing new genotypes in genetically depreciated populations, and we could set up a programme of reintroduction that gives the *A. grandiflora* populations the best chance to face global changes. We wanted to make the public at large participate in this ambitious programme of biodiversity conservation and we choose ninety students aged from eight to ten years, in the framework of an educational programme carried out by a wide community interest, to ensure the success of the project. In order to make their participation in the biodiversity conservation a permanent reflex in the mind of each student, we wanted them to have good memories of this experience: a personal diploma and the presence of the regional and national media allowed us to reach this aim.

Keywords

Participatory sciences, reintroduction sponsorship, primary school students, educational project, reintroduction diploma, glacial relict, hybrid populations, Community Interest.

The network of French Conservatoires Botaniques Nationaux: from research to public awareness.

In the late seventies, the French government entrusted the Conservatoires Botaniques Nationaux with the task of developing an original concept for plant conservation. Thus the network of Conservatoires Botaniques Nationaux was created to guarantee the plant biodiversity, thanks to four missions: (1) to know the situation and evolution of wild flora and natural & semi-natural habitats, using scientific methods; (2) to identify & conserve rare and endangered wild species and natural & semi-natural habitats; (3) to realize evaluations for the State and all local communities; (4) to inform and educate populations to know and protect plant biodiversity.

The Conservatoire Botanique National du Bassin Parisien is a laboratory of the French National Natural History Museum, located in Paris. Accordingly, our fifth mission is an applied research on very limited size populations of protected species, to understand their disappearance, and to set up efficient tools to face this evolution as well as to restore populations with capabilities of adaptation to the global changes.

A glacial relict near Paris: the reasons of its disappearance.

Arenaria grandiflora L. (Large-flowered Sandwort, *Fig. 1*) is a very rare caryophyllaceae in the lowlands of France. More common in the Pyrenean and Alpine regions (*Fig. 2*), it is considered as a glacial relict and is on the verge of extinction in the Fontainebleau forest, in the Parisian region. In this forest, *A. grandiflora* is an emblematic species because this is one of the oldest plant observation reported in the literature, by Tournefort in 1698.

The Conservatoire Botanique National du Bassin Parisien has been observing the species since 1995 and the results clearly showed that: (1) there were a small number of remnant individuals (*Fig. 3*); (2) a majority of plants did not flower; (3) a few capsules were produced; (4) the seeds are very often aborted; (5) among the very rare germinations, we observed a very low survival rate.

Further investigations made us able to understand why the species became so scarce in the Fontainebleau forest: besides the modifications of forestry practices, we found a low genetic diversity in comparison with upland populations and we have reliable indices of an inbreeding depression inside the Fontainebleau populations (*Fig. 4*).

Therefore, it became obvious that, considering the low number of remnant individuals in 2000 (only one) and the genetic patterns, the reintroduction scenario will be based on the increasing of the effective size, a combination of a higher number of individuals and a higher genetic level inside the reintroduced population. Indeed, the increased number of individuals reduces the effects of the demographic stochasticity and protects against the Allee effect, while increasing the genetic diversity prevents the population from inbreeding depression and enhances adaptive capabilities, almost in the context of threatened populations facing climate changes.

To make the coercive laws progress: the contribution of applied research.

However, the specifications of the Conservatoires Botaniques Nationaux are very clear and correspond with those of the IUCN: for reinforcement or reintroduction programmes, prefer the local material.

In 1999, we decided to experiment with the creation of eight hybrid populations of *A. grandiflora*, to study the benefit of supplementing the local genotypes with new blood and, maybe, to improve the laws and to change scientific minds. We placed two enclosures of one hundred square metres each in four sites in the Fontainebleau forest. Of course, the enclosures are far enough from the original populations to avoid gene flows between the threatened populations and the artificial ones (*Fig. 5*). In each enclosure, we reintroduced two hundred and twenty five individuals: one third were cuttings from Chinon, and two thirds of them were cuttings from Fontainebleau. We set up a specific monitoring protocol thanks to permanent quadrats with twines that are attached to the enclosures in which all plants are labelled (*Fig. 6*). The annual monitoring is carried out by the staff of the Conservatoire and each summer includes: floristic inventories, the enumeration of all living individuals, the evaluation of the mortality and the morbidity, the recruitment level, the plant size, the numbers of flowers per individual, the number of fruits, their size and their weight. Meanwhile, we developed molecular markers that enabled us to identify the parents of each new plant.

Finally, the experience gave us three main results: (1) we found that the descendants of Chinon are well adapted to their new environment (*Fig. 7*); (2) the hybrids between the two origins are more vigorous than the autochthone ones; (3) and we did not observe any crossbreeding depression. Therefore, it became obvious that the fitness of populations increases when new blood is brought into Fontainebleau's genotypes and, if we want to restore populations with improved adaptive capabilities, we have to supplement the local genetic diversity of the threatened populations of *Arenaria grandiflora* in the Fontainebleau forest.

To promote the Common Good by working together.

This applied research started in 1999 and up to now, we have only discussed it between scientists, while conservation biodiversity is supposed to benefit all. Moreover, since the beginning of the project, we encountered some difficulties in making this reintroduction

accepted by forest managers, users, associations, etc. We decided to involve more people in the reintroduction programme and we began with a discussion with the scientists and the land managers involved in biodiversity conservation, and at last, with the public at large.

It is very clear that everybody feels very concerned by biodiversity conservation and they seem motivated to participate in it. But when we address the issue of reinforcement or reintroduction, both the public at large and ecologists seem rather doubtful. Finally, when we address the issue of the benefit of mixed populations in reintroduction programmes, feelings turn to fear, almost like those about the issue of genetically modified organisms.

To whom will we bequeath the seeds we conserve?

Accordingly, because we generally encounter difficulties in changing adults ways of thinking, our goal was to involve young people in the reintroduction programme.

In 2008, we settled up an educational project with three Primary school classes, with a total of ninety students aged eight to ten years.

We chose two different schools : two classes were located in the city of Fontainebleau, thus in a very green environment, and the third one was located in the city of Thiais, very close to Paris, in a very urbanized environment and in a suburb where education was declared as a priority by the French Government.

We did not want the reintroduction programme to be only an operation about gardening, so we worked with the students in the framework of an educational project of which the aims were: (1) to involve them as soon as possible in the scientific process; (2) to make them understand what they do and why; (3) to make all of them participants and responsible for each aspect of the project; (4) and to establish it as a lasting experience in their minds.

Toward a wide community interest.

The construction of this project needed the support of many important partners, including: the National Center for Scientific Research, the Inspection of the Academy (a governmental structure in charge of the education in French regions), the councils, the early childhood services of the councils, the French Forestry Office, and the Ecology and Sustainable Development Ministry.

Preliminary works.

The first step of the educational project was a list of key words we gave to the teachers. Because of the complexity of scientific concepts needed for the reintroduction programme, like “inbreeding depression” or “*in vitro* micropropagation”, the teachers could introduce these terms, in order to avoid misunderstandings during the later stages of the programme.

A few months later, engineers, researchers and botanists gave them a three hour course to teach them: (1) about the importance of plants in our life; (2) to make them aware about scarcity, the disappearance of species and its consequences; (3) the threats that put the species on the verge of extinction; (4) the rule of citizens and their rule to prevent it; (5) their work on the field for *Arenaria grandiflora*; (5) the place this program has in the French history of conservation.

Two months later, we organized a tutorial session at the Museum and in our laboratory where each student had a stereo zoom microscope to observe seeds, with *A. grandiflora* ones. During the day, the students could isolate seeds of different species from soil samples thanks to an automatic sieve, and they sowed the seeds in plastic cups. Each student realized their own *in vitro* cuttings on *A. grandiflora* (*Fig. 8*) and they visited our seed bank and the conservatory garden where the plants to be reintroduced were cultivated. After this

tutorial session, each student went home with two souvenirs: (1) the plastic cup in which they sowed the seeds (the goal was to ask them if they can identify the species which will grow in the cups); (2) the test tube in which they placed the cuttings of *A. grandiflora*. Thus they could observe the development or not of their sample.

The "reintroduction day".

The "reintroduction day" was organized two months later. The classes were divided into five student groups, and each group was responsible for the plantation of twenty-five plants, by using a quadrat. Then they placed a permanent survey marker at the centre of each quadrat to facilitate the monitoring during the following years.

Each group had a survey data paper where the students noted their own measurements of the three individuals they planted (*Fig. 9*): the places inside the quadrat, the sizes of the plants, did the plants produce flower buds and their number.

At the end, they labelled each individual they planted with a permanent label and they wrote their own name on it, in the framework of a real sponsorship of this reintroduced species (*Fig. 10*).

The project did not finish with the plantation and we organized another field session at the flowering period. During one day, the students came to measure the development of their own plants, so they could make a rapid comparison with the former two months stages. After the summer holidays, the city of Thiais organized each September a fair for non-professional gardeners, and the students managed a booth to present their experience to the public at large during the 2009 fair. Finally, during the same day, they received a diploma.

Their first diploma.

The diploma we gave the students looks like an official one (*Fig. 11*). It contains the name of the student, the numbers of the three individuals each student planted, a picture of the student during the event, and was signed by the student, the director of the Conservatoire Botanique National du Bassin Parisien and by the General Director of the French Forestry Office.

The implementation of the GSPC.

Thanks to the many aspects of this programme, the Conservatoire Botanique National du Bassin Parisien widely contributes to the implementation of the GPSC, especially for the nine following targets:

1. **A widely accessible working list of known plant species, as a step towards a complete world flora.**

Since the beginning of this programme, the Conservatoire has been accumulating thousands of data for species belonging to the calcareous grasslands flora.

2. **A preliminary assessment of the conservation status of all known plant species at national, regional and international levels.**

The result of the monitoring protocol carried out during the last decade is a good knowledge of the conservation status of this glacial relict, as well as the very rare species that grows with *A. grandiflora*.

3. **Development of models with protocols for plant conservation and sustainable use, based on research and practical experience.**

We made much progress in the field of reintroduction of populations, with the experimentation of hybrid populations carried out in nature.

4. **At least 10% of each of the world's ecological region effectively conserved.**
5. **Protection of 50% of the most important area for plant diversity assured:**

Besides the reintroduction of *A. grandiflora*, the ecological restoration of the sites before the program allowed the conservation of open habitats like calcareous grasslands.

7. **60% of the world's threatened species conserved *in situ*.**
8. **60% of threatened plant species in accessible *ex situ* collections, preferably in the country of origin, and 10% of them included in recovery and restoration programmes.**

The program of reintroduction of *A. grandiflora* in nature was only possible because the species was cultivated *ex situ* and propagated *in vitro*.

15. **The number of trained people working with appropriate facilities in plant conservation increased, according to national needs, to achieve the targets of this Strategy.**

16. **Networks for plant conservation activities established or strengthened at national, regional and international levels.**

The wide Community Interest which made this programme possible facilitates at the same time the emergence of the biodiversity conservation in the main society concerns. This programme was widely covered by the media that helped the public at large to realize that concrete actions can be conducted for the benefit of the Common Good.

Fig.1 *Arenaria grandiflora* L.

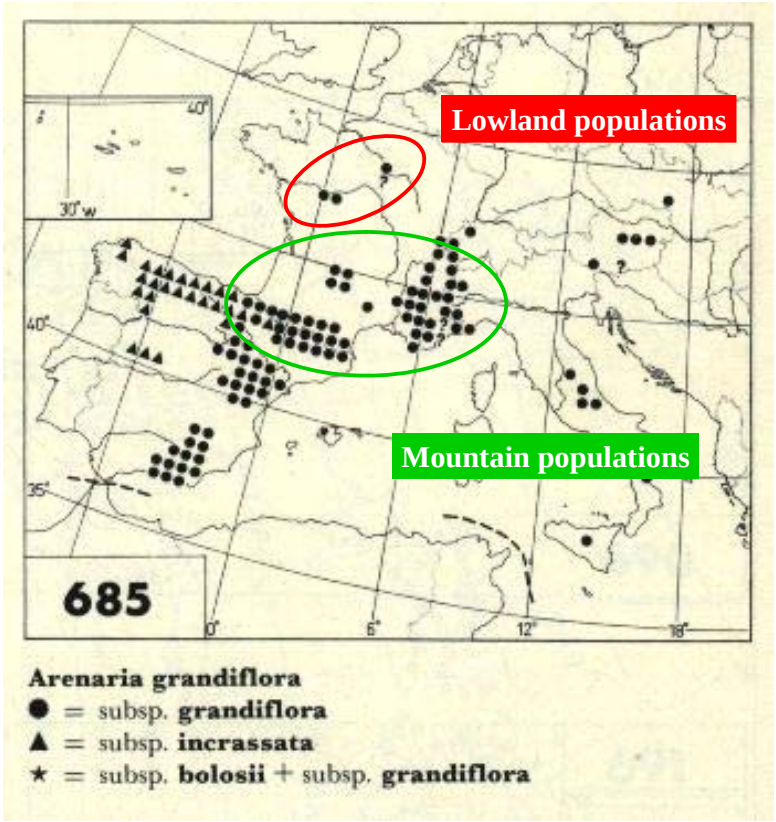


Fig. 2 Repartition area of *A. grandiflora*.

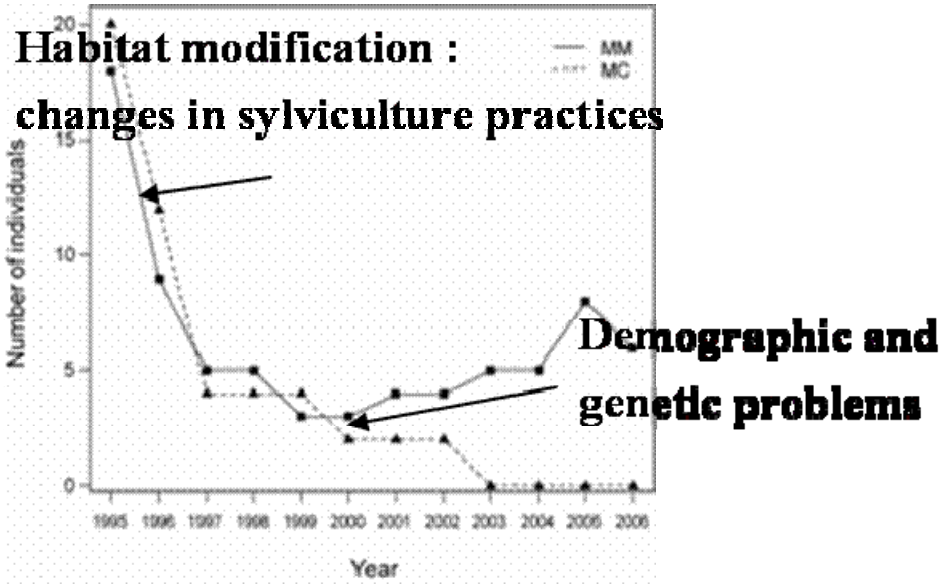
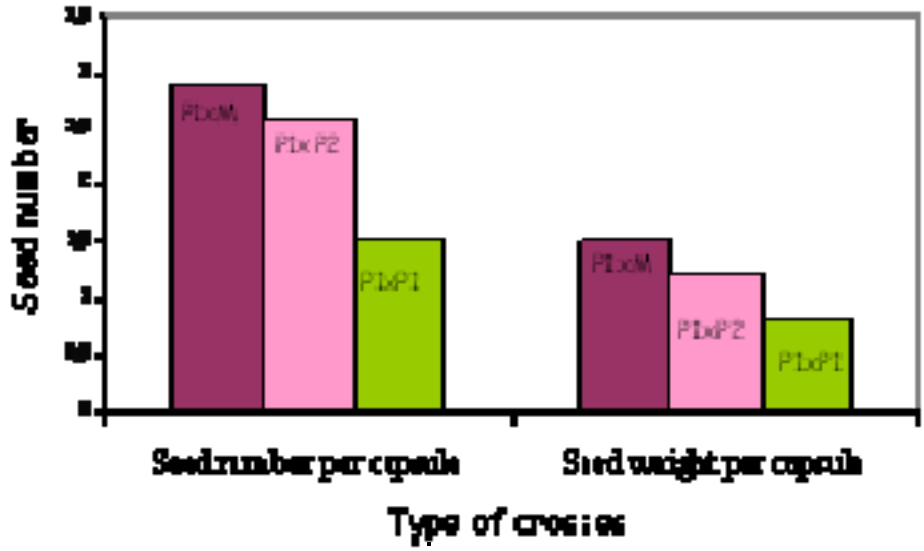


Fig. 3 Demography of the two populations of Fontainebleau forest over the last decade.



★ Fontainebleau x Fontainebleau (lowland crosses)
★ Fontainebleau x Chinon (lowland crosses)
★ Fontainebleau x Alpes (lowland/moutain crosses)

Fig. 4 Quality of the biology of the reproduction, according to the type of controlled crossing.

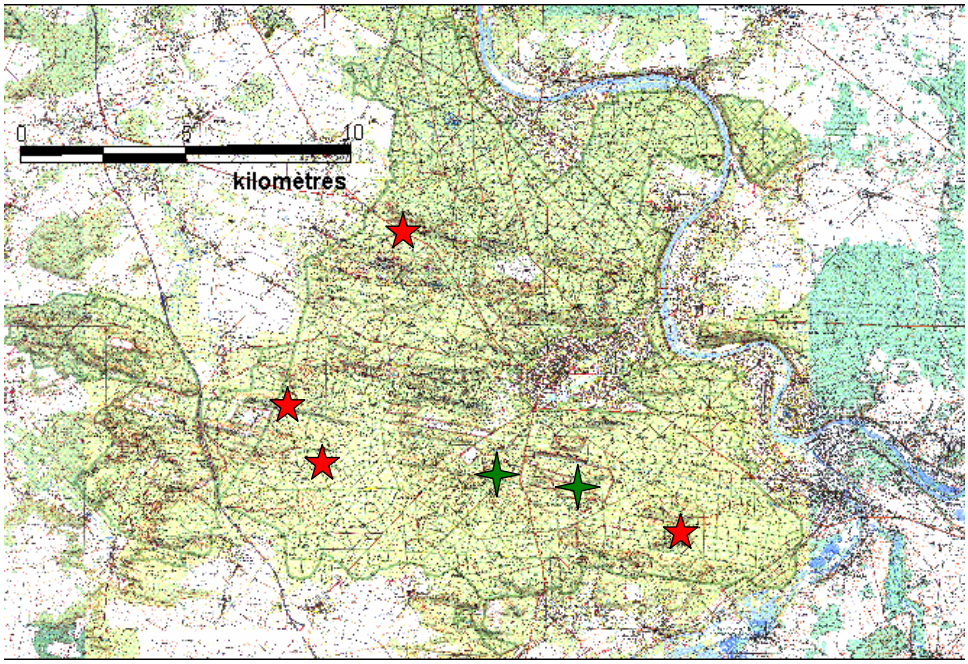


Fig. 5 Location of the experimental hybrid populations (in red) and of the original populations (in green).

Fig. 6 The monitoring protocol.

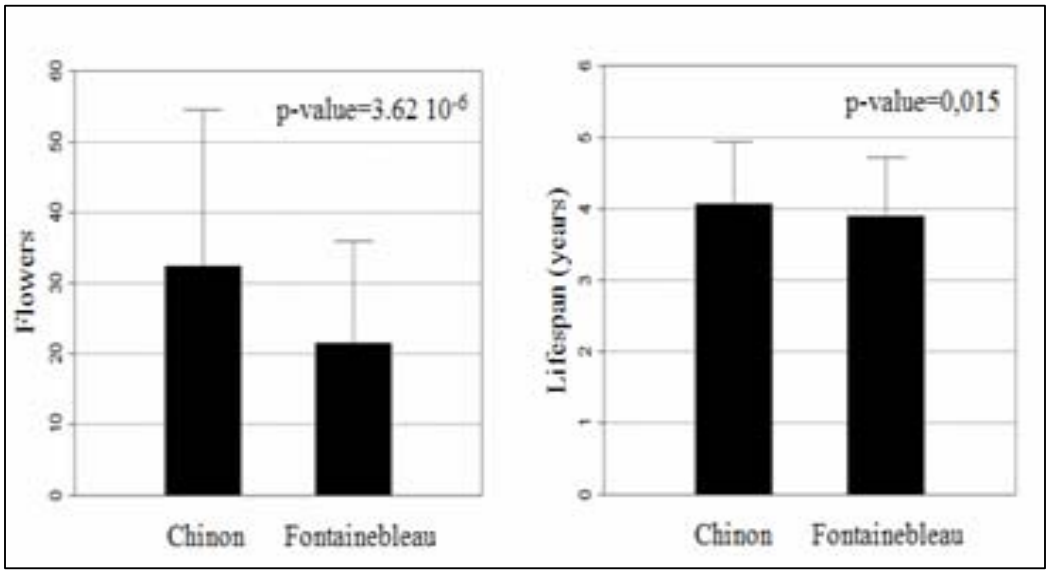


Fig. 7 One of the main results: the adaptation of the allochtonous genotypes to their new environment.

Fig. 8 Picture of the *in vitro* micropropagation experiment conducted by the students.

Fig. 9 Picture of one of the students during the plantation.

Fig. 10 A plant labelled with the name of its "Godfather".

Fig. 11 The diploma each student received after the project.