Bioversity International

MODULE 3
Tree seed supply chains

Introductory notes for teachers

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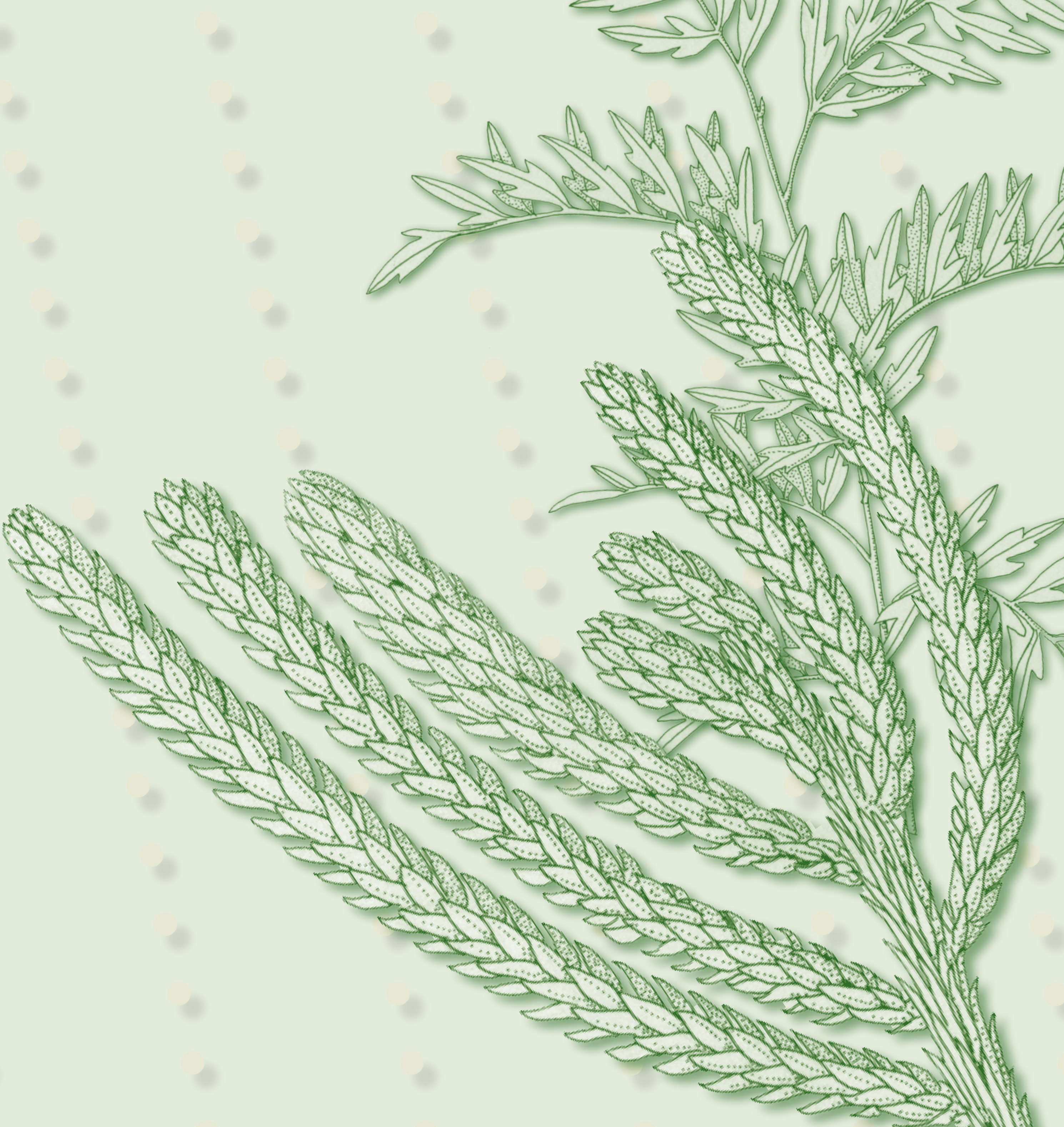

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Background

Tree planting, whether it is on farms or in commercial plantations, for forest restoration or species conservation, depends on a ready supply of germplasm (seed or vegetative material). Germplasm collection methods may vary, depending on the particular species or context. The need to use genetically diverse germplasm is, however, universal if plantings are to be productive, viable in the long term and resilient. Many tree species are outbreeding and generally carry a heavy genetic load of deleterious recessive alleles. Any inbreeding, in particular selfing, may thus have negative impacts such as reduced seed set and survival, leading to poorer regeneration, slower growth rates and productivity in progeny, limited environmental tolerance and increased susceptibility to pests and diseases. Consequently, maintenance of a wide genetic base will not only assist tree future adaptive capacity but also help to ensure that people continue to obtain the various benefits they derive from tree resources.

Intra-specific genetic diversity may, however, be limited by a number of factors. Farmers, nursery managers or commercial collectors may collect germplasm (seed or cuttings) from a small number of trees. Variability between trees in fertility can contribute to a rapid accumulation of relatedness and inbreeding in subsequent generations. Furthermore, after initial introductions, germplasm for subsequent generations of planting may be harvested from the same introduced trees, limiting subsequent inflows of new diversity. Genetic issues can also be of particular concern for nursery material where inbred seed may survive benign nursery conditions, leading to planting stock being genetically compromised.

Planting and successful establishment of diverse germplasm, for a range of species and provenances, also requires well functioning tree seed/seedling production and distribution systems to reach large numbers of scattered farms and relatively remote areas. This requires an appropriate combination of formal and informal, market and non-market channels, to stimulate and efficiently meet the varied and evolving demands of the range of clients (e.g. farmers, industrial, restoration, conservation) for quality seed.

Determining whether germplasm used on farms or in restoration and conservation programmes is genetically diverse or compromised is not straightforward. A number of approaches are available that can, either directly or indirectly, give insights into levels of genetic diversity and effective population sizes in collected germplasm. Molecular markers can directly compare genetic diversity and inbreeding in naturally occurring adults and seedlings with nursery material to distinguish genetic changes between wild adult and seedling cohorts, from those associated with nursery or seed collection practice. Such approaches are however costly and time-consuming and generally only applied to one species at a time.

Simple baseline surveys of the reproductive behaviour of relevant tree populations can indicate whether there are likely to be significant genetic problems in nursery material. Measures of variability among trees in flowering and viable seed set will indicate whether there may be high variability in the relative contribution of different trees to the next generation and hence a cryptic genetic bottleneck. Survey techniques (e.g. germplasm source surveys, on-farm tree inventories) can also offer alternatives that are more easily and more cheaply used simultaneously for many species. Such methods do, however, give less precise information and require more extrapolation.

Introduction to Module 3 Case studies

This Module allows students to consider how different parts of the germplasm supply chain affect genetic diversity in species. The two case studies present contrasting situations. The Araucaria study focuses on restoration efforts for an endangered species in a relatively well resourced country, whereas the study of nurseries in East Africa emphasizes the establishment of both native and exotic species on the land of resource-poor farmers. The module explores forest genetic resources aspects such as:

- Reproductive materials – source, collection and distribution
- Genetic processes associated with small populations – bottleneck, increased genetic drift, increased inbreeding and consequently homozygosity
- Effective population size compared to census size
- Sexual systems – dioecy, hermaphrodite
- Self-incompatibility mechanisms

Case study 3.1 Bottlenecks in the restoration of Araucaria nemorosa. This case study presents information from ecological and genetic research on a critically endangered tree species endemic to a narrow area of a Pacific Island (New Caledonia). Conservation actions for the species are focussed on restoration that involves seed collection and planting at a number of sites. Students are asked to describe the seed supply chain, identify the genetic risks associated with current practices and devise a strategy for collection and use of seed that ensures maintenance of genetic diversity in restoration efforts. Suits 1-3 groups of 4-5 students per group.

Case study 3.2 Tree planting on farms in East Africa: how to ensure genetic diversity? This case study presents information from research on tree seed sourcing by nurseries, seed supply chains, and the roles of different organizations in Kenya, Tanzania and Uganda and the implications of current practices for genetic diversity. In particular, the study covers the extent of seed tree sampling and germplasm exchange. This allows students to explore influences on genetic diversity associated with seed collection and distribution paths and to derive specific actions to improve diversity in the seed system (e.g. practical ways to collect and distribute seed/seedlings to ensure genetic diversity in nurseries and in material planted in the field). Suits 1-3 groups of 4-5 students per group.

How to use the case studies

The case studies are designed for use as class exercises on devising conservation strategies for specific tree species, where a lot of information is available. Teachers can use one or both of the two case studies, depending on geographic interest, particular conservation issue, class size and availability of time. Although the case studies are tropical, extensive testing shows they are suitable for students from tropical and non-tropical countries alike. If class sizes are larger than the numbers indicated, it is better to use both case studies from the same module, rather than increasing the size of each group. If groups are larger than six, some students tend to not contribute to the discussion and work of their group.

Each case study consists of:

- **The Case study –** introduces the exercise to be assigned to the students and presents information from research on the particular species or forest genetic resources issues.
- **Teacher's notes –** give extensive tips on how to prepare and run the exercise and discuss the main learning points that students should be able to derive from the case study.
- **Additional background information –** can be used to introduce the case study to the students. It includes video and PowerPoint presentations.
- **Reference materials –** include PDF files of key publications relevant to the case study.

The exercises can be run in a number of ways depending on the time available and size of the class. The exercises work best if students work in groups of 4-5 (no more than six). It is best if the students have already read the case study before they start the exercise. *This way valuable class time is not lost with students reading the paper during the class.* So give the case study out in a previous class with instructions to read it before the next class. It perhaps goes without saying that it is vital that the teacher and any assistants are fully familiar with the whole text. Each exercise last approximately 3 hours, broken down as follows:

- **Introduction:** use the video and/or PowerPoint – *approx. 30 minutes*.
- **Group work:** students discuss the case study amongst themselves, responding to the specific points and developing their strategy. The teacher should be around to answer any queries the groups have. However it is not essential that all of the time is spent with the whole class together with the teacher. Once the teacher and groups are happy they understand the assignment and issues they could meet, discuss and prepare the strategy outside of class time – *1.5 hours*.
- **Presentations:** each group presents its strategy verbally to the class (supported by main points written on large paper or in a PowerPoint presentation) – *10 minutes per presentation*, with *5 minutes* after each presentation for questions or comments by the rest of the class and the teacher.
- **Final discussion:** led by the teacher allowing them to make general comments about what was good, what was missed, etc. – 10 *minutes.*

Key background publications

General background to issues raised in this module

The following documents can be found on the accompanying DVD, or at the Forest Genetic Resources Training Guide webpage at www.bioversityinternational.org. They give more background to the issues raised in this module and can be used by the teacher to strengthen their knowledge and help give ideas about the topics. NB: the three Forest Genetic Resources Conservation and Management volumes: volume 2 (FAO et al. 2001); volume 1 (FAO et al. 2004a); volume 3 (FAO et al. 2004b) have examples from both tropical and temperate ecosystems. The Finkeldey (2005) book is of more direct relevance to tropical contexts, whereas the Geburek and Turok (2005) book is of more direct relevance to the temperate and, in particular, the European context.

Tree seed supply chain themes

- *Where is the species? How many populations? Which ones? How large? What information is needed?* FAO et al. (2004a) pp. 37-47; FAO et al. (2004b) pp. 9-16; Finkeldey (2005) pp. 185-187.

- *Reproductive materials - source, collection and distribution* FAO et al. (2004b) pp. 9-16, 41-42; Finkeldey (2005) pp. 76, 158-161, 188-189; Geburek and Turok (2005) pp. 448-456, 548-553, 567-570.
- *Participatory approach* FAO et al. (2004a) pp. 54-57, 70-71.
- *Assumptions/misconceptions about local communities* FAO et al. (2004a) pp. 58-60.
- *Glossary of genetics terms* FAO et al (2004a) pp. 103-106; FAO et al. (2001) pp. 87-90; FAO et al. (2004b) pp. 83-86.

Boshier DH. 2004. Agroforestry systems: important components in conserving the genetic viability of native tropical tree species? In Schroth G, Vasconcelos H, Harvey CA, Gascon C, Fonseca G, editors. Agroforestry and Biodiversity Conservation in Tropical Landscapes. Island Press, USA. pp. 290-314.

Dawson IK, Lengkeek A, Weber JC, Jamnadass R. 2009. Managing genetic variation in tropical trees: linking knowledge with action in agroforestry ecosystems for improved conservation and enhanced livelihoods. Biodiversity and Conservation 18:969-986.

Dawson IK, Vinceti B, Weber JC, Neufeldt H, Russell JR, Lengkeek AG et al. 2011. Climate change and tree genetic resource management: maintaining and enhancing the productivity and value of smallholder tropical agroforestry landscapes. Agroforestry Systems 81:67-78.

Dhakal LP, Lillesø J-PB, Kjær ED, Jha PK, Aryal HL. 2005. Seed sources of agroforestry trees in a farmland context - a guide to tree seed source establishment in Nepal. Forest & Landscape Development and Environment Series 1-2005, Hørsholm, Denmark.

FAO, DFSC, IPGRI. 2001. Forest genetic resources conservation and management. Vol. 2: In managed natural forests and protected areas (*in situ*). International Plant Genetic Resources Institute, Rome, Italy.

FAO, FLD, IPGRI. 2004a. Forest genetic resources conservation and management. Vol. 1: Overview, concepts and some systematic approaches. International Plant Genetic Resources Institute, Rome, Italy.

FAO, FLD, IPGRI. 2004b. Forest genetic resources conservation and management. Vol. 3: In plantations and genebanks (*ex situ*). International Plant Genetic Resources Institute, Rome, Italy.

Finkeldey R. 2005. An Introduction to Tropical Forest Genetics. Institute of Forest Genetics and Forest Tree Breeding, Georg-August-University Göttingen, Germany.

Geburek T, Turok J, editors. 2005. Conservation and management of forest genetic resources in Europe. Arbora Publishers, Zvolen, Slovakia.

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