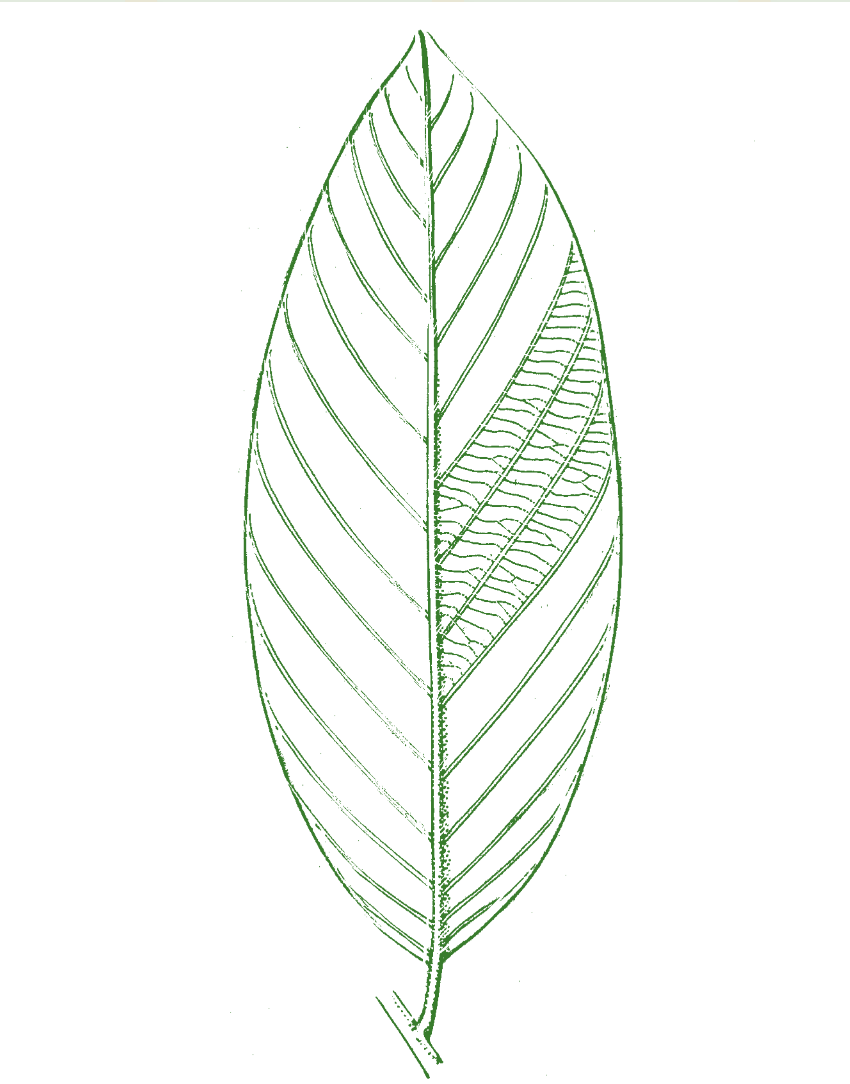
Bioversity International

MODULE 1
Species conservation strategies

Teacher's notes 1.3

Shorea lumutensis: genetic variation and conservation

David Boshier



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MODULE 1
Species conservation strategies

Teachers Notes 1.3

Shorea lumutensis: genetic variation and conservation

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Introduction

These Teacher's notes aim to assist teachers in using the Case Study 1.2 ***Shorea lumutensis: genetic variation and conservation*** in classes. The notes:

- describe the key concepts covered in the case study, with references to forest genetic resources textbooks where explanations can be found (full references at the end of these notes).
- give tips on how to prepare and run the exercise and discuss the main learning points (genetic and other) that students should be able to derive from the case study.
- give an outline commentary to the PowerPoint presentation which is used to introduce the case study to the students. The presentation contains pictures of the species, reserves where it occurs, relevant land-use issues in the area, and figures/tables from the exercise.

The following support materials can be found on the accompanying DVD, or at the Forest Genetic Resources Training Guide webpage at www.bioversityinternational.org

- Teacher's PowerPoint presentation.
- Video that gives general background to logging and conservation of dipterocarp forest in Malaysia.
- The Case Study.
- PDF files of the two papers that form the basis for this case study. More details of issues can be found in these papers (Lee & Krishnapillay 2004, Lee *et al*. 2006).

Key concepts to cover/introduce in this Case Study

General conservation

- ***In situ, ex situ* conservation:** see FAO et al. (2004a) pp 5-16, 33; FAO et al. (2001); FAO et al. (2004b); Finkeldey (2005) pp 181-198; Geburek & Turok (2005) pp 6-8, 535-562, 567-581.
- **Biological corridors:** see FAO et al. (2004a) pp 43-44; FAO et al. (2001) pp 45-47, 64; Boshier et al. (2004).

Genetic concepts

- **50/500 rule and effective population size compared to census size:** see FAO et al. (2004a) pp 43-44; FAO et al. (2001) pp 7, 10, 61; FAO et al. (2004b) 10-12; Finkeldey (2005) pp 177, 181-198; Geburek & Turok (2005) pp162-164, 420-431; Lee et al. (2006) p85.
- **Genetic processes associated with small populations – increased genetic drift, bottlenecks, increased inbreeding and consequently homozygosity:** see FAO et al. (2004a) pp. 43-44; Finkeldey (2005) pp. 75-76.

How to run the exercise

The exercise can be run in a number of ways depending on the time available and size of the class. The exercise works 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. NB: the exercise is set in the context prior to the year 2007, both in terms of the species status and country profile. As such, more recent information and changed contexts are not included as they are not relevant to the exercise.

Ideal number of students: 4-15.

Ideal length of class: 3 hours, divided as follows:

Introduction: use the video followed by the PowerPoint - *approx. 20 minutes*.

Group work: suits 1-3 groups of 4-5 students each. Each group devises a strategy, but tends to take a different approach and different issues are raised, such that overall, most points are covered. 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, each group 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 PowerPoint) - *10 minutes per presentation*, with 5 minutes after each presentation for questions or comments by the rest of the class and teacher.

Final discussion: led by the teacher allowing the students to make general comments about what was good, what was missed, etc. - *10 minutes.*

Background information

Video: this lasts 5 minutes and gives general background to logging and conservation of dipterocarp forest in Malaysia. It is of most use for groups who have not seen this type of forest before and can be excluded if the class is familiar with the context.

PowerPoint: about 15 minutes to go through. This gives background to *S. lumutensis*, showing the conditions in which the species occurs, but also allows explanation of some specific issues raised in the students'case study.

Slide 2 - photos of *S. lumutensis* leaves, flowers and fruits.

Slide 3 - map showing species distribution in peninsular Malaysia restricted to five reserves in one region.

Slide 4 - photo showing the type of hill forest where the species occurs and the number of trees left.

Slides 5 to 7 - photos of the *S. lumutensis* populations illustrating particular threats to each population.

Slide 8 - shows the need for research if conservation is to be effective.

Slide 9 - shows the main topics that were researched and provide the basis for the results presented in the study. It is important to note that ecological and genetic studies are complementary and not either/or.

Slide 10 - shows the demographic survey that was carried out.

Slide 11 - shows the main results of the population dynamics survey.

Slide 12 - covers alternative objectives for conservation. The teacher must stress the need for students to define an objective for their conservation strategy. It is very common for students to not define a strategy or to forget to explain what it is. Without this, it is impossible to judge the efficacy of a conservation strategy. Objectives should be pertinent and realistic and avoid the "operation was a success, but the patient died" syndrome, i.e. we carried out all the activities successfully, but it did nothing to help.

Slides 13 to 14 - cover the issue of population size. Relate the values in this slide to the population sizes in the students' text (see Conservation status, page 4) and how overlapping generations mean that the effective population sizes of these remnants will be lower than the census number.

Slides 15 to 18 - summarise different approaches to conservation and associated problems. The emphasis should be on their complementary nature rather than either/or. The relative emphasis on *in situ* or *ex situ* will shift depending on the characteristics of the species and population of concern.

Slides 19 - shows part of Table 4 and allows the teacher to highlight the variation in allele frequencies across populations. Certain alleles occur at high frequency in most populations (e.g. *Slu110-222, 224*; *Slu124-137, 153*; *Slu175-220, 226*). Some alleles have higher frequencies in only one or a few populations and so give an indication of differentiation between the populations, reflecting the impact of population size and gene flow (*e.g. Slu110-220*SM; *Slu124-133*TM, *165LU*; *Slu175-221*TM).

Slide 20 - allows the teacher to explain the significance of Table 3 and the dendrogram (Fig. 2) in the exercise, i.e. which populations are more closely related genetically to each other. You can point to the idea that this can help in prioritising which populations to conserve, although the data show that there is actually little differentiation. Table 3 shows that the geographical distances between the populations are very small and the overall distribution covers only 20 km.

Slide 21 - allows the teacher to explain the significance of Table 5 and Figure 3 for the exercise, i.e. from Table 5, the species shows mixed mating (some trees mainly outcrossed and some trees with a high degree of selfing) and the mean distance of pollen flow. The breeding unit size relates to the number of different pollen parent genotypes represented in a maternal tree's fruit crop. Breeding unit area is calculated from the paternity analysis estimates of breeding unit size and the census densities of adult, reproductively mature trees. Figure 3 shows the results of a simulation to calculate how many trees would be needed to maintain the current levels of genetic diversity in the populations.

Slides 22 to 24 - allow the teacher to go over what the students should be doing in the exercise. The teacher should stress: a) the need to be specific in what the strategy includes – students tend to be too general in their recommendations; b) the need to prioritise – students tend to recommend doing everything, failing to recognise that resources for these actions are extremely limited; c) they should indicate what information/evidence they have used to justify each recommended action; d) they need to present a convincing case that would sway a donor/ government to give them funds and/or enact policy or legislation to conserve the species.

Important points to draw out in discussion and to cover in students' strategies

Comments about the questions in the Case Study

Suggested conservation actions and background are detailed in the Lee et al. *(*2006) paper (see PDF file in accompanying DVD)

■ *How has human disturbance shaped the genetics of S. lumutensis?*

From the text (*Distribution* section, page 2), students should identify that there is no concrete evidence that the species' overall distribution was much larger than it currently is. The specificity of the species' habitat requirements suggests its distribution is naturally rather small and possibly also naturally fragmented due to habitat availability. In the region, humans may have destroyed stands of the species on hillsides that are now deforested and it is clear that population sizes are greatly reduced due to human activity. However, the greatest human impacts are likely to be in the future, rather than the past, unless action is taken.

■ *What are the mating system, seed and pollen dispersal mechanisms?*

See *Phenology* section (page 2) and Genetic variation section (page 7; Table 5). The species shows mixed mating (some trees mainly outcrossed and some with a high degree of selfing). Both the pollinator (thrips) and seed dispersal mechanism suggest that most gene flow is likely to be over relatively short distances. Thrips are poor flyers however, and it is likely they move passively over larger distances than expected through wind-mediated transport, hence the medium range pollination distances seen in Table 5.

■ *What are the levels of genetic variation and how are the alleles distributed across populations?*

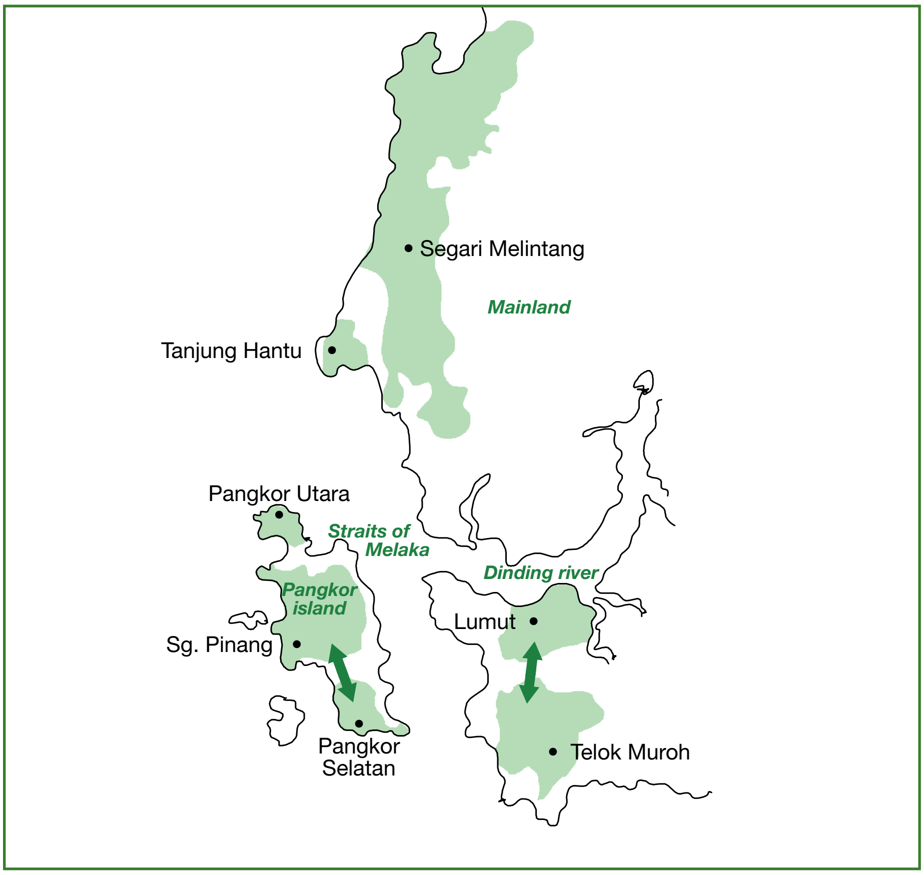
Levels of genetic variation are high, which is typical of SSR markers. Some alleles occur at high frequency in most populations (e.g. *Slu057-110*, *112, 114*; *Slu110-222, 224*; *Slu124-137, 153*; *Slu175-220, 226*; *Sle111a-149, 157*; *Sle267-116, 126*). Also typical of SSR markers is a large number of alleles at low frequency (e.g. *Slu057-118, 121, 122, 123, 124, Slu124-141*; *Sle111a155*). Some alleles have higher frequencies in only one or a few populations (e.g. *Slu110-220*; *Slu124-133,165*; *Slu175-221*; *Sle111a-151*; *Sle267-118, 130, 132*), giving an indication of differentiation between the populations (Fig. 2) and reflecting the impact of population size and gene flow. There is, however, little genetic differentiation between the populations (5.8% of genetic variability distributed among populations - see Genetic variation in natural populations section in case study; low support for the branches in Fig. 2 from bootstrap), such that the species could be viewed as consisting of just one population spread across the five reserves. This means that it is debateable whether conservation efforts should try to ensure each of the five reserves is maintained as a separate population.

List problems by type

Genetic

■ *Which populations are too small?*

All the populations are too small – the largest is about 120 (Segari Melintang). Effective population sizes will be much lower due to overlapping generations. There is potential for genetic erosion due to drift. Deforestation outside the reserves may reduce the extent to which there is gene flow (pollen/seed dispersal) between the reserves and thus increase the chance of genetic erosion



due to drift and hence increase genetic differentiation between the populations. The most effective way to counter genetic risks is to allow for migration, i.e. the exchange of pollen and seeds. The idea of habitat corridors initially developed for animal conservation may be an option, and, provided that resources are available, could be used to link the closer populations (see Figure above). Table 3 shows the distances between the reserves, and Table 5 pollen flow distances. From the standard deviations, pollen flow across distances of 500 m will not be uncommon. Increasing the frequency of pollen flow could also be facilitated by planting of *S. lumutensis* trees in vegetation patches between the reserves to act as genetic stepping stones/corridors.

Others

■ *What are the threats to S. lumutensis (short-term and long-term)?*

Short-term threats are mainly deforestation, a lack of knowledge about *S. lumutensis*. Long-term, the small population size of the populations threatens the species in terms of both stochastic (chance) threats and evolutionary adaptability.

■ *For which populations is action a priority and of what type should this be?*

Generally speaking, the priority should be to conserve those populations with the greatest chance of viability (genetically and in a social context), which together cover the range of genetic diversity within the species. However, in this study, there is little differentiation between the populations and all the populations are of similar size and under threat. The proximity of the populations also means that any stochastic events (e.g. a cyclone) may affect all simultaneously. Given that the populations occur within existing reserves, there is no need to prioritise action for one reserve above another. The remaining five populations should be legally designated as strictly protected areas. Monitoring of the reserves to check that populations are being maintained or not decreasing in size will be essential. This requires gathering of baseline data to allow changes (positive and negative) to be identified.

■ *What are the limiting social factors to conservation, utilisation and planting?* These are human pressures on the remaining forests/trees and the lack of knowledge about *S. lumutensis*. Given the species' slow growth rate it is unlikely that conservation can be promoted through its *ex situ* planting in commercial plantations. However seed produced from *ex situ* conservation could be used in ecological restoration.

Students' strategies should indicate

Which *conservation methods - in situ*, *ex situ*?

- *In situ*: the priority should be for *in situ* conservation of all five populations with a strengthening of the protected status of the reserves.

- *Ex situ*: a seed collection to conserve the species/populations *ex situ* would be worthwhile to avoid loss of the genetic resources in the face of any catastrophic destruction of the populations *in situ*. However, as seed production is episodic and long-term seed storage is problematic, the material should then be established *ex situ* as a conservation stand. The strategy should specify details of the seed collection, e.g. combine seeds collected from all five populations. Collect equal quantities of seed from at least 10 trees per population with seed trees separated by 200 m to ensure sampling of different pollen pools. This would ensure sampling from >50 mother trees and many more pollen sources.

What *do end-users need to know and how will you communicate that?* Those involved in land management within the species' natural distribution (e.g. local communities, government agencies, companies, developers, landowners) need to know about the rarity of *S. lumutensis* and the global importance of the reserves. Malaysia, as a signatory of the Convention on Biodiversity, has an obligation to ensure protection of the species. A conservation strategy should link to local community activities. Production of targeted information (e.g. posters/leaflets) is required. It is worth noting that this study showed that numbers of *S. lumutensis* trees are higher than the original figure given in the IUCN assessment (see Conservation status and Introduction sections of student case study). This illustrates the type of inaccuracy associated with some IUCN species designations. The information needs to be incorporated into the IUCN status for the species.

Who *will do* ***what*** *and* ***where****?* Under the Malaysian constitution, land is a state responsibility with each state empowered to enact laws and to formulate policy independently (see Country profile). Designation of conservation areas is brought about by state legislation. To ensure the conservation areas are functional, it is urgently needed that the state government confers a 'strictly protected' status upon the areas. The establishment of *in situ* conservation areas will not only conserve *S. lumutensis*, but also help to conserve the entire ecosystem including many non-targeted species, such as *Eurycoma longifolia* in Sungai Pinang.

How *will you pay for it*? It is vital students understand that resources for conservation are limited and therefore require a prioritisation of actions depending on what is available. Conservation efforts need to be targeted where scarce resources can be most effective. The main actions outlined above are limited, but feasible. Seed collection would require additional funds, while communication of the importance and advantages of *S. lumutensis* requires a modest budget that could also benefit from a redirection of existing resources.

Further information

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Forest Genetic Resources Training Guide

MODULE 1 Species conservation strategies

1.1 *Leucaena salvadorensis*: genetic variation and conservation

1.2 *Talbotiella gentii*: genetic variation and conservation

1.3 *Shorea lumutensis*: genetic variation and conservation

MODULE 2 Trees outside of forests

2.1 Conservation of tree species diversity in cocoa agroforests in Nigeria

2.2 Devising options for conservation of two tree species outside of forests

MODULE 3 Tree seed supply chains

3.1 Genetic bottlenecks in the restoration of *Araucaria nemorosa*

3.2 Tree planting on farms in East Africa: how to ensure genetic diversity?

MODULE 4 Forest management

4.1 Impacts of selective logging on the genetic diversity of two Amazonian timber species

4.2 Does selective logging degrade the genetic quality of succeeding generations through dysgenic selection?

4.3 Conserving *Prunus africana*: spatial analysis of genetic diversity for non-timber forest product management

MODULE 5 How local is local? – the scale of adaptation

5.1 Selecting planting material for forest restoration in the Pacific north-west of the USA

5.2 Local adaptation and forest restoration in Western Australia

Other modules to be published among the following:
Plantation forestry, Tree domestication, Forest restoration, Genetic modification