Forest Ecology and Management 333 (2014) 1–8

Contents lists available at ScienceDirect

Forest Ecology and Management

journal homepage: www.elsevier.com/locate/foreco

# Seeing the trees as well as the forest: The importance of managing forest genetic resources

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ARTICLE INFO

*Article history:*
Available online 18 September 2014

*Keywords:*
Rural livelihoods
Germplasm transfer
Indicators
Climate change
Restoration
*Ex situ* conservation

ABSTRACT

Reliable data on the status and trends of forest genetic resources are essential for their sustainable management. The reviews presented in this special edition of Forest Ecology and Management on forest genetic resources complement the first ever synthesis of the State of the World's Forest Genetic Resources (SOW-FGR) that has just been published by the Food and Agriculture Organization. In this editorial, we present some of the key findings of the SOW-FGR and introduce the seven reviews presented in this special edition on: (1) tree genetic resources and livelihoods; (2) the benefits and dangers of international germplasm transfers; (3) genetic indicators for monitoring threats to populations and the effectiveness of ameliorative actions; (4) the genetic impacts of timber management practices; (5) genetic considerations in forest ecosystem restoration projects using native trees; (6) genetic-level responses to climate change; and (7) *ex situ* conservation approaches and their integration with *in situ* methods. Recommendations for action arising from the SOW-FGR, which are captured in the first Global Plan of Action for the Conservation, Sustainable Use and Development of Forest Genetic Resources, and the above articles are discussed. These include: increasing the awareness of the importance of and threats to forest genetic resources and the mainstreaming of genetic considerations into forest management and restoration; establishing common garden provenance trials to support restoration and climate change initiatives that extend to currently little-researched tree species; streamlining processes for germplasm exchange internationally for research and development; and the intelligent use of modern molecular marker methods as genetic indicators in management and for improvement purposes.

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## 1. Introduction

Reliable data on the status and trends of tree genetic resources of present or potential benefit to humans are required to support the sustainable management of perhaps as many as 100,000 tree species found globally inside and outside forests (Oldfield et al., 1998). Recognising the importance of these resources and the need for information, the first ever synthesis of the State of the World's Forest Genetic Resources (SOW-FGR), which focuses on the 'tree' component of forests, has just been published by the Food and Agriculture Organization (FAO, 2014a). The production of this report – which involved synthesising information collected in a common format by 86 countries that together account for over 85% of global forest cover – represents a milestone in assembling the knowledge needed to better manage forest genetic resources nationally and internationally.

To accompany the SOW-FGR, a series of expert-led thematic studies on tree genetic resources was commissioned by the FAO. These were the starting point from which the reviews that make up this special issue of Forest Ecology and Management were developed. In this editorial, we first present some of the key findings of the SOW-FGR, before introducing the content of the reviews. We conclude with recommended priorities for future action, which generally coincide with the Strategic Priorities of the first Global Plan of Action for the Conservation, Sustainable Use and Development of Forest Genetic Resources (FAO, 2014b), based on the findings of the SOW-FGR. The series of articles in this special issue celebrates the heightened recognition – especially through the publication of the SOW-FGR – of the value of forest genetic resources globally, resources that previously received scant attention despite their importance. The articles presented here are also a lament, however, for the ongoing often unnoticed loss of

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http://dx.doi.org/10.1016/j.foreco.2014.08.014
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these resources, which erodes the opportunities for developing new tree products, and limits the evolutionary potential of forests to respond to environmental change and other global challenges. Geburek and Konrad (2008) discussed reasons why the conservation of forest genetic resources has not worked, including difficulties in assessment, in assigning value and in coordinating management. This series of articles lays out some reasons why such conservation is imperative and recommends actions towards resolving some of the challenges.

Starting with the SOW-FGR itself: of the approximately 8,000 taxa of trees, shrubs, palms and bamboo cited as useful in the individual Country Reports compiled to produce the global report – which represent around a quarter of all the woody perennials estimated to be used regularly by humans (FAO, 2014a) – 42% are indicated to be used for timber and 41% for non-wood forest products (NWFPs). The SOW-FGR indicates that around 30% of these species are actively managed for their products and services, while about half of the 8,000 are indicated to be threatened in some way. Despite their importance and notwithstanding the level of active management indicated by Country Reports, only about 700 of these tree species were recorded to be subject to tree improvement programmes, while the SOW-FGR indicates that genetic parameters have been described for only approximately 1% of all tree species.

Country Reports listed almost 2,300 tree species as national priorities for conservation and management, with economic value in the formal economy a major factor in prioritisation. Country Reports indicated that relatively little attention is given by national compilers of use data to the value of tree products and services in the informal economy, despite their high importance here (as related by Dawson et al., 2014, this special issue). Of the above species, approximately 500 were nominated as priorities for management at least in part for negative reasons related to their invasiveness potential (explored in this special issue by Koskela et al., 2014). The most common priority species globally was teak (*Tectona grandis*), followed by river red gum (*Eucalyptus camaldulensis*), white poplar (*Populus alba*), Norway spruce (*Picea abies*) and common leucaena (*Leucaena leucocephala*) (mentioned by 21, 19, 15, 14 and 14 individual Country Reports, respectively). Taking these five tree species as examples, many of the countries assigning them as priorities for action did not have them occurring naturally, which indicates a strong need for international coordination in conservation and management efforts, something that is indicated by a number of authors in this special issue (e.g., Dawson et al., 2014; Koskela et al., 2014). Four of the five are also mentioned as invasive species in at least one country, hence part of the reason for the overall priority ranking is negative considerations, indicating the necessity for caution in transferring even the most highly valued germplasm among countries.

Country Reports also listed approximately 1,800 tree species conserved *ex situ* in seed banks, botanic gardens and elsewhere, with approximately 600 of these belonging to the aforementioned category of priority species. Without doubt, this significantly under represents the number of tree species stored *ex situ*, however, as illustrated by the large number of entries in the Tree Seed Suppliers Directory (TSSD), a database that lists more than 5,800 woody perennial species available globally through seed suppliers' active collections (Dawson et al., 2013; TSSD, 2014). Furthermore, the Millennium Seed Bank (MSB, Kew, UK) currently holds seed of over 10% of the world's wild plant species in long-term storage– including a very wide range of trees – and by 2020 aims to hold 25% (MSB, 2014). A significant problem remains, however, in the limited genetic representation of these collections due to narrow sampling and the lack of passport data that accompanies accessions (Dawson et al., 2013). More data and better coordination of collections are clearly required. Better coordination is also needed between *ex situ* and *in situ* efforts. Although it is generally agreed that *in situ* conservation is the first line of defence, it is only in Europe that reserves known as dynamic gene conservation units are established systematically to conserve tree genetic resources (Lefèvre et al., 2013).

## 2. Trees and livelihoods

The first review by Dawson et al. (2014) in this special issue of Forest Ecology and Management considers the value of tree genetic resources for tropical rural communities. What is known and what is assumed about value for different tree products and services? Actual benefits are often not well quantified as exemplified by the Country Reports of the SOW-FGR, where little quantitative information is given. Reasons for this gap in knowledge include ubiquity of use and an absence of appreciation of the benefits of trees and their genetic resources (Byron and Arnold, 1997; Dawson et al., 2009; de Foresta et al., 2013). For example, while Dawson et al. (2014) indicate that there are many citations in the literature to the importance of NTFPs, until a decade ago few of these studies were designed in a way to allow well-thought through development interventions (Belcher and Schreckenberg, 2007). The situation has much improved in the last decade, however, with a number of wide-ranging systematic reviews and meta-analyses being undertaken, culminating recently in the work of the Poverty Environment Network (Angelsen et al., 2014; PEN, 2014). Even today, however, in most cases of NTFP extraction the importance of considering genetic factors in management – such as the breeding system and the effective population size of the source plants – are not given much consideration (Ticktin, 2004).

Agroforestry practices have been widely adopted globally (Zomer et al., 2009) and farm landscapes contain many planted and retained forest trees (AFTD, 2014; Dawson et al., 2013). Although some attention has been paid to the genetic improvement of trees for timber and food production in smallholder agroforestry systems, little attention has been given to trees used for soil fertility replenishment and animal fodder production, despite potential benefits for productivity and green house gas emission reductions (Fisher and Gordon, 2007; Ray, 2002). Further attention to the genetic improvement of indigenous fruit trees, which harbour high intraspecific variation in production traits, has also been recognised as an important intervention for smallholders' livelihoods (Leakey et al., 2012). Notwithstanding the livelihood and environmental benefits, some authors have argued that further tree domestication in farmland should not be promoted because it could have negative impacts for inter- and intra-specific genetic diversity in agricultural landscapes; however, without improvements in yield and quality, farmers may choose not to plant trees at all, which would likely result in a worse situation (Sunderland, 2011).

The major tree commodity crops have all been subject to a degree of formal breeding (Mohan Jain and Priyadarshan, 2009), and landrace and wild populations – often still found in forests – have an important role to play in tree crop development. There are limited mechanisms for production to support the conservation of these latter stands, however, and more attention is required in developing approaches that share costs and benefits. A good illustration Dawson et al. (2014) quote is that of coffee (*Coffea* spp.) production. In this case, Brazil is the largest global producer, but wild forest coffee (*Coffea arabica*) is found in the threatened forests of the Ethiopian highlands: how, then, can Brazil support coffee conservation in Africa (Labouisse et al., 2008)? Another case is apple (*Malus domestica*), which is grown globally but whose centre of origin is Central Asia, where populations of the principal progenitor, *Malus sieversii*, are vulnerable to loss (Williams, 2009). Deter-

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