

## Is there a need for a forest restoration certification scheme?

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### Abstract

We propose the development of a certification scheme for forest ecosystem restoration that aims for the adoption of protocols and guidelines to ensure the sustained ecological and social value of restored ecosystems. Despite an accumulation of experience on ecosystem restoration over the past decades, it is still common to measure the success of restoration mainly in terms of number of seedlings planted or their survival in the short term. A strong focus on planting targets may divert attention from the actual objectives: establish self-sustaining forested ecosystems that provide livelihood or other ecosystem service benefits to local people. Two important determinants of short and long term success, which often do not receive sufficient attention, are matching the right seed source to the planting site conditions and ensuring that restored populations of trees have sufficient genetic variability to be self-sustaining.

Because of the enormous scale of land degradation and the funds being pledged to tackle it, standardized measures of success are of increasing importance. Restoration success needs to be evaluated in a holistic way by restoration practitioners, government institutions, civil society organizations, private sector and, importantly, funding agencies.

Much is known about how to restore ecosystems in different regions and under different conditions, however currently there is no consensus on what success looks like or what the minimum criteria should be for monitoring and documenting success. Success can be achieved by following well defined practices and protocols (eg by ensuring high diversity both at species and genes levels, number of mother trees for the collection of reproductive material, provenance, etc) during the various phases of the restoration process. We make a case for the development of a certification system to support long term value of restored populations for global application.

*Keywords: Forests and landscape restoration, forest restoration, forest ecosystem restoration, Certification, forest reproductive material*

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### Introduction, scope and main objectives

Restoration of forest landscapes is carried out for many reasons, different approaches are taken in different situations and scientific evidence has been created to compare different approaches to forest restoration practice (Stanturf et al 2014). We will focus on the restoration initiatives that aim to (re)establish functioning, self-sustaining forested ecosystems by planting mainly native tree species that have socio-economic value to local people.

In many cases, restoration projects involving tree planting are implemented without attention to some of the key factors to ensure success. This may lead to wasting precious resources and missed opportunities. Among the success factors that are most commonly overlooked are the most basic – ensuring that the planting material is well-suited to the project objectives such as improving livelihoods of local people or mitigating climate change. In practice this means that, in addition to ensuring that the planted species will be useful for local people, the planting material used for restoration must be capable of surviving, growing and reproducing in restored self-sustaining ecosystems.

There are various approaches for achieving better consideration of the often-neglected success factors in restoration, ranging from the normative – improving legal frameworks with new or strengthened regulations and policies – to purely voluntary application of guidelines. Establishing a certification system to verify that genetic and other important criteria for restoration success are met is an intermediate approach that we think merits exploration.

In this article we explore the case for application of indicators and a certification system that would include measures to predict the suitability and genetic diversity of germplasm for restoration.

## **Importance of genetic considerations in restoration**

A longterm goal of forest ecosystem restoration is that established tree populations be viable over generations, meaning that not only do the trees exhibit good survival and growth, but they can successfully reproduce, with vigorous regeneration to sustain the restored populations across generations. Both the origin and genetic diversity of forest reproductive material (FRM) significantly affect the survival, growth, and productivity of trees and the adaptive capacity and hence self-sustainability of tree populations (Reed and Frankham 2003; Schaberg et al 2008). If the planting material is not well-matched to the planting site, failure manifested as high seedling mortality may be observed within the first two or three years after planting. Alternatively, it may become apparent when environmental conditions approach extremes, i.e. high mortality may occur in a drought year or a particularly cold winter or the young trees may be highly susceptible to insect or disease attack. A 30,000 ha plantation of *Pinus pinaster*, sourced from the Iberian Peninsula of Spain and planted in the Landes region of France provides an example. The Spanish source was susceptible to frost, and was destroyed during the exceptionally cold winter of 1984/1985 (Timbal et al., 2005). Choosing the most appropriate forest reproductive material (FRM) can be particularly challenging because the degraded sites may be harsher than normal conditions because of, for example, erosion, soil compaction, and absence of shade. With the added complication of changing climates, identifying the best planting material may require a modelling approach such as used by Gray and Hamann (2011) to find seed sources that are adapted to the already changed or predicted conditions of the restoration site.

In addition to choosing suitable seed sources to be well adapted to planting sites, and bearing in mind the climatic change that has already occurred in some cases, planting material which has a narrow genetic base also has consequences for longterm viability of restored populations. If seed is collected from a very small number of trees, (five trees or less) for use in local restoration problems will likely become apparent the planted trees reach reproductive maturity. Seed set and germination are likely to be low because of a high frequency of inbreeding (Broadhurst et al 2008) because when all of the seed comes from very few trees, many of the trees in the neighborhood of any planted tree will thus be full or half-siblings, resulting in inbred offspring. This may jeopardize the long-term viability and capacity to adapt of restored forests and reduce productivity in subsequent generations because, particularly if there is little gene flow from beyond the planting site, the first generation of planted trees plays a key role in subsequent natural regeneration. If the founder population is established using FRM from one

inbred population or from a very small number of trees, the consequent inbreeding and low genetic diversity may result in reduced fitness in the first or subsequent generations (Reed and Frankham 2003; McKay et al 2005). For example, inbred second and third generation seedlings of *Acacia mangium* showed significantly reduced growth compared to the original introductions to Sabah (Malaysia) from Australia in 1967. The original introductions represented a very small genetic base (Sim 1984).

Genetic diversity is positively related to the functioning and resilience of the whole ecosystem (Gregorius 1996; Reusch et al 2005; Sgrò et al 2011) in addition to the viability of tree populations (Reed and Frankham 2003; Schaberg et al 2008). Genetic diversity is also vitally important for adaptation of tree populations to changing site conditions which occurs through natural selection. Natural selection is effective only when genetic diversity is present in the traits that influence survival, growth and reproduction; when those traits are heritable; and when populations are large enough to allow for high selection intensity. In order to establish self-sustaining forest ecosystems through restoration, collections of FRM must capture broad diversity in adaptively important traits for the target planting species. This means collecting seed from sufficiently large populations and from many unrelated trees (a minimum of 30-60 widely spaced trees; more if vegetative propagules are used; Kindt et al. 2006; Rogers and Montalvo 2004). Alternatively, if restoration relies mainly on natural regeneration, seed sources near the restoration site must be genetically diverse.

The importance of using appropriate germplasm was recently recognized by the 12th Conference of the Parties to the United Nations Convention on Biological Diversity, which called for due attention to genetic diversity and the use of native species in ecosystem restoration (Decision XII/19, 2014).

## **What needs to be measured?**

A certification system to verify good practice in restoration would need to include the important success factors and measurable indicators relating to planting stock quality. The key intrinsic variables relating to suitability of the planting material are genetic diversity and adaptation to site conditions. Neither of these is easy or quick to measure directly, requiring that monitoring be carried out over decades. Thus proxies are needed for practical application.

*Genetic diversity:* Guidelines for tree seed collection have been developed to help ensure a minimum level of genetic diversity in the planting stock, but appear to be largely unknown or overlooked by restoration practitioners or those who supply germplasm for restoration (Bozzano et al 2014; Thomas et al 2014; Godefroid et al 2011).

Proxies for genetic diversity include estimates of number of mature trees in source populations, and the number and distribution of seed source trees within the populations.

*Adaptation:* Seed zoning approaches have been used in reforestation, particularly in North America and Europe for decades, however even if seed zones were developed and rigorously applied in restoration, it may not be sufficient in the current conditions of rapidly changing climate. The common preference for planting stock from local sources (McKay et al 2005; Sgrò et al 2011; Breed et al 2013) needs to be revisited and scientific evidence produced to formulate alternatives.

Excessive emphasis on 'local' germplasm may overlook the fact that geographic proximity to the restoration site is not necessarily the best indicator of the quality or suitability of germplasm. In addition, in the degraded soils that typify restoration sites, conditions may be very different from those under which local populations originally developed. Environmental mosaics may result in geographically distant sites having similar ecologies, while closer sites differ.

The best way to ascertain the most suitable seed sources for planting under various environmental conditions is to use provenance trial data if they exist or to establish new provenance tests, including reciprocal transplants. Ideally this will be built into restoration projects in the future. Recognising that restoration cannot wait for field results, however, an alternative approach is to predict suitability of seed sources based on modelling. Environmental conditions, including predicted future climate at the restoration site, can be matched with similar current environmental conditions and planting material sourced from those locations.

### **Why consider a certification scheme?**

The massive scale of restoration plans and initiatives indicates a high commitment to restoring productivity to degraded lands. However past experience does not lead to confidence in the success rate of such endeavors. There are few records of success rates past the establishment phase of restored sites, so little is known about success in establishing viable populations from a genetic perspective. For plant reintroductions in general, a global literature review and survey of 249 reintroductions showed that survival, flowering and fruiting rates were low, averaging 52%, 19% and 16%, respectively (Godefroid et al. 2011). Survival rates reported in published literature (78%) were much higher than those given by survey respondents (33%). Knowledge of genetic diversity of the target species positively influenced reintroduction outcomes, especially over time (Godefroid et al. 2011). However from a rich forestry literature, we do know how to predict success using indicators that can be measured at the time of establishment (see for example, Graudal et al 2014).

The purpose of a certification scheme would be to ensure that practitioners use internationally recognized good practices to improve short and long-term success in forest and landscape restoration, including self-sustainability of restored populations of trees. For the purpose of this article, we define certification in the broad sense, as a formal procedure by which an authorized person or agency verifies that certain characteristics, qualities or processes meet particular criteria. Any certification scheme would need to be supported by capacity strengthening programmes, considering the currently limited capacities and awareness regarding the use and importance of appropriate FRM in forest and landscape restoration efforts, and the proliferation of actors involved in restoration resulting from global attention to the topic.

### **Possible approaches towards implementation**

Integrating assurances of diversity and proper sourcing of FRM in relevant existing initiatives can be an effective way to improve practices on a broad scale relatively rapidly. For example, several standards and guidelines related to Reducing Emissions from Deforestation and Forest Degradation (REDD+) that can serve as a framework for integrating FRM considerations and monitoring their implementation and impacts are already available or under development. These include the UN-REDD framework for supporting the development of country approaches to REDD+ safeguards (UN-REDD Programme 2013), the Social and Environmental Principles and Criteria (UN-REDD Programme 2012), and guidelines for assessing ecosystem services of restored forests (Doswald et al. 2010). Inclusion of standards and guidelines for the source and diversity of forest reproductive material could enhance effectiveness of REDD+ projects in terms of carbon sequestration, considering the fundamental role of genetic diversity for species' and populations' adaptation to changing environments. Such adaptive capacity is a prerequisite for survival and sustained biomass production and, consequently, carbon sequestration for mitigating climate change, the main purpose of REDD+.

Another example of existing relevant initiatives is forest certification, schemes for which have been developed and implemented around the world. However, there is usually no expectation that planted commercial forest will be self-sustaining, which is a fundamental difference from restored forest.

An approach that is under consideration in the context of 20x20 Initiative -a country-led effort to restore 20 million hectares of land in Latin America and the Caribbean by 2020- is voluntary certification of nurseries, including commercial or public ones, and nurseries that are established for a particular project.

The OECD has developed a *Scheme for the Certification of Forest Reproductive Material* to encourage the production and use of FRM that have been collected, processed, raised, labelled and distributed following good practices and in a verifiable manner. Only FRM from identified, selected or tested sources is considered to comply with OECD rules, and such sources do not often exist, or are inadequately managed, for species of interest in forest restoration in the respective countries. As well, the rules only extend to seed quality, and do not include guidance on seedling production or matching seedlings to planting sites. Nevertheless, the rules, regulations and guidelines under the Scheme could serve as a useful model for gradually improving FRM collection and production practices and availability of appropriate sources of FRM in forest restoration context.

Certification comes at a cost related to the independent verification of adherence to the certification standard. However, assuming that verification of good practice will increase the success rate, when the price of certification is weighed against the cost of failed restoration efforts, both in terms of the high cost of replanting and the less readily quantifiable costs associated with missed opportunities (ecosystem services, livelihoods), the benefits would likely outweigh the costs.

## **Conclusions/outlook**

The magnitude of current restoration initiatives poses great opportunities but also risks of failure. Important factors in success of restoration initiatives, including adaptedness of material to planting sites and the genetic diversity of planting material, are frequently overlooked. Success can be achieved by following well defined practices and protocols during the various phases of the restoration process. One approach to improving likelihood of success is through a certification scheme that would include criteria for genetic considerations as well as other factors that are important for successful forest ecosystem restoration. Such an approach will require a broad consultation with restoration practitioners, government institutions, civil society organizations, funding agencies and other stakeholders, to create a common understanding and for the development of generalised consensus.

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