GfÖ
GfÖ Ecological Society of Germany, Austria and Switzerland
Basic and Applied Ecology 11 (2010) 300–311
Basic and Applied Ecology
www.elsevier.de/baae

A question of origin: Where and how to collect seed for ecological restoration

Kristine Vander Mijnsbrugge[a,*], Armin Bischoff[b,1], Barbara Smith[c]

[a]*Research Institute for Nature and Forest, Gaverstraat 4, B-9500 Geraardsbergen, Belgium*
[b]*University of Fribourg, Unit of Ecology and Evolution, Chemin du muse 10, CH-1700 Fribourg, Switzerland*
[c]*The Game and Wildlife Conservation Trust, Burgate Manor, Fordingbridge, Hampshire SP6 1EF, UK*

Received 30 January 2008; accepted 4 September 2009

Abstract

Native plant species are routinely planted or sown in ecological restoration projects, but successful establishment and survival depend on where and how seeds are collected. Research suggests that it is important to use locally adapted seeds. Local populations often show a home-site advantage and non-local genotypes may be maladapted to local environmental conditions. Furthermore, intraspecific hybridisation of local and non-local genotypes may have a negative impact on the genetic structure of local populations via mechanisms such as outbreeding depression. Many species show a strong small-scale genetic differentiation between different habitats so that matching habitats of the restoration and donor site can be more important than minimizing geographical separation. It is a challenge to identify appropriate seed sources because strong small-scale population differentiation makes it difficult to delineate geographically defined seed zones to which seed exchange should be limited. Moreover, it is important to consider the genetic diversity of introduced material because it may be crucial to avoid genetic bottlenecks, inbreeding depression and poor establishment of plant populations. Repeated propagation in stock, which is often required to obtain a sufficient amount of seeds, can further reduce genetic diversity and may select for particular genotypes. Negative impacts of improper seed choice for nursery planting stock may become detectable only after many years, especially in long-lived and slow growing plants. Although scientific information on many species remains limited, the increasing demand for translocation of seed means that mandatory regulations are necessary. Guidelines should prescribe a specification of seed provenance, a record of genetic diversity of wild collections and rules for subsequent processing such as direct transfer and propagation of stock or seed orchards. We use a literature review to evaluate current legislation and to develop recommendations for herbaceous and woody species.

Zusammenfassung

Es ist heute gängige Praxis, heimische Pflanzenarten zu Renaturierungszwecken auszubringen. Die erfolgreiche Etablierung hängt jedoch davon ab, wie und wo das Saat- oder Pflanzgut gewonnen wurde. Forschungsergebnisse legen nahe, dass nur lokal angepasste Herkünfte eingesetzt werden sollten. Es ist vielfach festgestellt worden, dass sie eine höhere Fitness als fremde

*Corresponding author. Tel.: +32 54 43 71 46; fax: +32 54 43 60 66.
E-mail address: Kristine.VanderMijnsbrugge@inbo.be (K. Vander Mijnsbrugge).
[1]Present address: Agrocampus West, Centre of Angers, Institute of Horticulture and Landscape Planning (INHP), Department of Biological Sciences, UMR 1099 BiO3P, 2 rue André Le Nôtre, F-49045 Angers, France.

1439-1791/$ – see front matter
doi:10.1016/j.baae.2009.09.002

Herkünfte besitzen, und letztere sind daher schlecht an lokale Umweltbedingungen angepasst. Eine intraspezifische Hybridisierung mit gebietsfremden Populationen kann weiterhin einen negativen Einfluss auf die genetische Struktur von lokalen Populationen haben wie z.B. outbreeding depression. Einige Arten zeigen eine starke kleinräumige genetische Differenzierung zwischen verschiedenen Habitaten, so dass die Übereinstimmung von Spender- und Renaturierungsflächen wichtiger sein kann als eine minimale Entfernung. Diese kleinräumige Differenzierung macht es schwierig, geographische Regionen festzulegen, innerhalb derer ein Austausch von Pflanzenmaterial unbedenklich ist. Darüber hinaus muss die genetische Diversität des gesammelten und eingeführten Materials berücksichtigt werden, um genetische Flaschenhälse, Inzuchtdepression und eine geringe Etablierungsrate zu vermeiden. Eine wiederholte Kultivierung und Vermehrung von Pflanzenarten, die oft notwendig ist, um eine ausreichende Samenmenge zu produzieren, kann zu einer weiteren Reduktion der genetischen Diversität beitragen oder zu einer Selektion bestimmter Genotypen führen. Negative Auswirkungen einer ungeeigneten Auswahl von Herkünften werden insbesondere bei langlebigen und langsam wachsenden Arten häufig erst nach vielen Jahren feststellbar. Angesichts des wachsenden Bedarfs an Wildpflanzensaatgut sind verbindliche Regelungen notwendig, auch wenn die Datenlage für viele Arten immer noch unzureichend ist. Diese Richtlinien sollten Vorgaben zur Herkunft und Diversität des Saatgutes bei der Sammlung am natürlichen Standort machen und die nachfolgende Prozesskette von der Saatgutreinigung und Lagerung über die Vermehrung bis hin zur Ausbringung regeln. Unter Verwendung von Literaturdaten bewerten wir die gegenwärtige Gesetzgebung und entwickeln Empfehlungen sowohl für krautige Pflanzen als auch für Gehölze.

Keywords: Seed provenance; Commercial seed collection; Home-site advantage; Local adaptation; Habitat differentiation; Seed collection zones; Inbreeding and outbreeding depression; Seed transfer; Seed orchard

Introduction

In the last two centuries the human impact on the world's ecosystems has increased and natural habitats have been degraded. During recent decades, interest has grown among conservationists, restoration practitioners, forest managers and landscape designers, in restoring altered landscapes, woodlands and forests back to more 'natural' ecosystems, which are rich in native species. Currently, native herbaceous plant species are routinely sown in ecological restoration projects and, the use of indigenous woody species instead of exotics is standard in European forestry. A major challenge for restoration practitioners is to consider genetic variation and diversity within native species (Walker, Hodder, Bullock, & Pywell 2004).

Population differentiation within plant species is well documented. This differentiation is partly driven by local adaptation resulting in a home-site advantage for the offspring. For example, provenance trials of trees and shrubs showed that stock of British origin is better adapted to British conditions than continental stock (e.g. Jones, Hayes, & Sackville Hamilton 2001; Worrell 1992). Here we use the term 'local' as a synonym for autochthonous, i.e. to mean that the populations originate where found, and by extension, are adapted to local environmental conditions. Local adaptation in herbaceous species can occur rapidly, e.g. on soils contaminated with heavy metals (Antonovics 2006). For long-lived species such as trees, adaptation to variable environmental conditions such as climate, 'local' is assumed to imply a continuous existence at a specific site since post-glacial immigration (Kleinschmit, Kownatzki, & Gregorius 2004). However, while it is often assumed (using the rationale we outlined above) that local populations are superior to non-local populations, there have been several studies demonstrating that non-local populations can have a higher fitness (e.g. Bischoff, Vonlanthen, Steinger, & Müller-Schärer 2006b; Crespi 2000; Saltonstall 2002).

Four mechanisms have been identified through which the introduction of non-local genotypes may have negative consequences (e.g. Edmands 2007; Krauss, Zawko, Bussell, Taylor, & Hood 2005; McKay, Christian, Harrison, & Rice 2005).

- Non-local genotypes may suffer from maladaptation to the local environment resulting in a lower fitness. For long-lived perennials problems may only be evident many years after seemingly successful establishment.
- Intraspecific hybridisation of local and introduced genotypes may result in outbreeding depression, i.e. reduced fitness in subsequent generations due to the introgression of maladaptated genes or due to hybrid breakdown. Hybrid breakdown describes the disruption of positive epistatic interactions among co-adapted gene complexes, and its negative effects on fitness are often delayed until the F2 or later generations (Edmands 2007; Hufford & Mazer 2003).
- Occasionally, introduced genotypes are superior to local ones and become invasive. Such a spread of alien genotypes is called cryptic invasion because it is much more difficult to detect than the spread of alien species (Hufford & Mazer 2003; Saltonstall 2002).
- The introduction of non-local material may have negative effects on associated plant and animal species. Imported hawthorn has been shown to flower up to 5 weeks earlier than native hawthorn, potentially threatening the insects and birds whose reproductive cycles are synchronized with this event (Hubert & Cottrell 2007). The implications of using non-local seed for resident invertebrate herbivores are uncertain, but there is some evidence that invertebrates