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Species shifts in above-ground vegetation and the soil seed bank in the inter-dune lowlands of an active dune field in Inner Mongolia, China

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Abstract

Degradation of semi-arid ecosystems leading to desertification presents a global environmental challenge. However, few studies have investigated seed bank and above-ground species composition in degraded semi-arid dune systems, particularly in relation to their potential to contribute to stabilisation and revegetation. We determined whether soil seed bank and above-ground species composition differed along a chronosequence in the inter-dune lowlands of an active dune field in Inner Mongolia, China. Soil cores were collected in early April 2011 and soil seed bank composition determined using a combination of the seedling emergence and seed extraction methods. Established vegetation, including species composition and abundance, was also surveyed. Relative importance values for all above-ground species and similarities in species composition of vegetation and soil seed bank along the chronosequence were analysed. A clear successional trend was shown for established vegetation along the first three stages identified, followed by a final stage reverting to more mobile substrate due to disturbance by dune movement. This trend was not reflected in the seed bank. Plant and seed bank density increased over time, however, species composition of the seed bank reflected earlier stages rather than the corresponding established vegetation. There was a relationship between established vegetation and the soil seed bank at the earliest stage, driven mainly by the persistence of seeds of the pioneer species *Agriophyllum squarrosum* and *Corispermum candelabrum*. A relatively close relationship was also found at the final stage, where frequent disturbance occurred as a result of increasing sand burial, caused by constant directional sand dune movement. While a clear relationship between the seed bank and associated vegetation was not found along the whole chronosequence,

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the seed bank displayed potential for restoration of pioneer psammophytes and annual herb species, suggesting that it would contribute to regeneration, as well as support latter-stage annuals and several rare and endemic species.

Zusammenfassung

Die Degradation von semi-ariden Ökosystemen, die zur Desertifikation führt, stellt eine globale Umweltherausforderung dar. Indessen haben nur wenige Studien die Samenbank und die oberirdische Artenzusammensetzung in degradierten semi-ariden Dünensystemen untersucht, insbesondere in Hinblick auf die Stabilisierung und Wiederbegrünung. Wir bestimmten, ob die Samenbank im Boden und die oberirdische Artenzusammensetzung entlang einer zeitlichen Entwicklungsreihe in den Dünentälern eines aktiven Dünenfeldes in der Inneren Mongolei (China) differierten. Bodenproben wurden früh im April 2011 gesammelt, und die Samenbank wurde mit einer Kombination aus Keimungsversuchen und Samenextraktion bestimmt. Die vorhandene Vegetation, einschließlich der Artenzusammensetzung und Abundanz, wurde ebenfalls registriert. Die 'importance values' (IV) der oberirdischen Arten und die Ähnlichkeiten in der Artenzusammensetzung von Vegetation und Samenbank wurden entlang der Entwicklungsreihe analysiert. Ein eindeutiger Sukzessionstrend wurde für die Vegetation der ersten drei Stadien identifiziert, gefolgt von einem Endstadium, das zu einem mobileren Substrat infolge der Störung durch die Dünenbewegung zurückkehrte. Dieser Trend zeigte sich nicht in der Samenbank. Die Pflanzendichte und die Samenbank nahmen im Laufe der Zeit zu. Allerdings entsprach die Artenzusammensetzung der Samenbank eher früheren Sukzessionsstadien als der aktuellen Vegetation. Es gab eine Beziehung zwischen der vorhandenen Vegetation und der Samenbank im ersten Sukzessionsstadium, die hauptsächlich durch die Persistenz der Pionierarten *Agriophyllum squarrosum* und *Corispermum candelabrum* bestimmt war. Eine relative enge Beziehung wurde auch im Endstadium gefunden, in dem häufige Störungen auftraten, weil zunehmend Pflanzen durch die gerichtete Bewegung der Sanddüne verschüttet wurden. Während eine klare Beziehung zwischen Samenbank und der assoziierten Vegetation nicht über die gesamte zeitliche Entwicklungsreihe gefunden wurde, zeigte die Samenbank das Potential für eine Restaurierung von Pionier-Psammophyten und krautigen Annuellen, was nahelegt, dass die Samenbank zur Regeneration beitragen sowie Anuelle späterer Sukzessionsstadien und seltene und endemische Arten unterstützen könnte.

Keywords: DCA; Chronosequence; Soil seed bank; Inter-dune lowland; Floristic composition; Restoration

Introduction

The soil seed bank is an important component of ecosystem resilience and represents a stock of regeneration potential in many plant assemblages (Hagen, Geelen, & de Vries, 2008). It is especially important for the regeneration of vegetation in habitats where disturbance is frequent (Fenner & Thompson, 2005), such as mobile dunes. Seeds are able to disperse into, accumulate and subsequently germinate in areas devoid of vegetation, such as those found where dunes are forming, to begin the formation of a vegetation layer that will stabilize the sand and form a dune (Leicht-Young, Pavlovic, Grundel, & Frohnapple, 2009). Some species overcome periods of unfavourable weather conditions by building up a large seed bank. For species with this strategy, species diversity is preserved and information on seed bank strategy and structure is retained (Yassir, van der Kamp, & Buurman, 2010). Pioneer species establishment is the initiation of community succession, and soil seed banks can be used to predict the composition of new plant recruitment (Allen & Nowak, 2008).

Inter-dune lowlands are topographic depressions which develop between active dunes, and occur as small, naturally fragmented systems in the dune landscape (Bossuyt, Honnay, & Hermy, 2003; Liu, Li, Yan, & Wu, 2007). In semi-arid dune ecosystems, such as in Inner Mongolia, this landscape consists of a mosaic of mobile dunes, semi-fixed and fixed dunes, and lowland meadows, with a single predominant wind direction (Zhang, Zhao, Zhang, Zhao, & Drake, 2005). The environment contrasts with that on the adjacent active dunes, and fluctuates throughout the year, maintaining standing water in the winter, but prone to drought stress in summer (Stark, Lundholm, & Larson, 2003). Specialised dune plant species are able to withstand mobile sand, burial, drought, high temperatures, salt winds, and low substrate nutrient levels (Gunster, 1994; Pake & Venable, 1996; Stark et al., 2003; Sykes & Wilson, 1987). Subsequently, inter-dune lowlands provide refuge for a relatively large number of rare and endangered species (Gunster, 1994), and are a crucial habitat for the reproduction and survival of invertebrates, amphibians, and other wildlife (Everard, Jones, & Watts, 2010; McLachlan, Kerley, & Rickard, 1996; Peralta-Pelaez & Moreno-Casasola, 2009). It is therefore important to understand the structure and function of inter-dune lowlands, especially to examine vegetation patterns at the dune scale and its relationship with environmental factors in the restoration processes of mobile dunes (Liu et al., 2007). This will improve predictions regarding this resource in the future and guide management decisions for conservation or restoration measures (McLachlan et al., 1996).