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Influence of former cultivation on the unique Mediterranean steppe of France and consequences for conservation management ☆

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Abstract

In Europe, the actual landscape has been mainly influenced by human activities. Agricultural intensification led to a considerable habitat loss and fragmentation, especially for dry semi-natural grasslands.

This current study investigates the impact of former melon and cereal cultivation (cultivation period: 1950–1987) on the semi-natural vegetation of the Crau, representing the last xeric Mediterranean steppe in France.

Today, the ex-cultivated melon and cereal fields are characterised by different vegetation compositions, species richness and evenness compared to the undisturbed steppe community. Also the abiotic conditions (N, P, K, pH, soil granule fractions) have been changed by former cultivation practices. The rather transient seed bank of the steppe was depleted during the cultivation periods; ancient weed species and ruderals now determine the seed bank of the ex-cultivated fields.

It is concluded that the conservation of the last parts of undisturbed steppe must have absolute priority. A re-development of the original and unique steppe community on formerly cultivated fields may take decades or centuries, if at all.

Keywords: Crau; Dry grassland; Restoration ecology; Seed bank; Secondary succession

1. Introduction

Within the last few decades, agricultural intensification led to a considerable floristic change and decrease of semi-natural ecosystems in Europe (Hodgson and Grime, 1990; Akinola et al., 1998; Poschlod et al., 1998; WallisdeVries et al., 2002). Many formerly continuous types of grassland have become extinct or fragmented, and in most cases only small and isolated patches of ancient remnants remain. In such fragmented landscapes, restoration of ex-arable fields on ancient grasslands plays a major role as restored sites could enlarge and connect these remnants. The restoration depends on the abiotic (e.g. soil fertility) and biotic conditions of the abandoned arable fields (e.g. modified competitive interactions; Saunders et al., 1991) and on temporal and spatial dispersal abilities of the characteristic species of the target community (Poschlod et al., 1998).

In north-western Europe, the short-term (Austrheim and Olsson, 1999) and long-term (Wells et al., 1976) effects of ploughing on present-day dry calcareous vegetation were clearly identified. Ex-cultivated plots showed a decrease in species-richness and changes in their botanical composition compared with adjacent dry grasslands. Cultivation, however, also influences the direction taken by post-cultural plant succession (Gibson and Brown, 1991). This phenomenon is linked to increased soil fertility of ex-cultivated plots because of ancient fertiliser applications during the cultivation period (Gough and Marrs, 1990) and the presence of ruderal species (*sensu* Grime, 1979), which are known to have persistent seeds in the soil (Graham and Hutchings, 1988a,b; Dutoit and Alard, 1995; Dutoit et al., 2003).

☆ Nomenclature: Kerguélen (1999).

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However, also seeds of target species might survive the cultivation period in deeper soil layers, providing the fact that ploughing were not too deep (Bekker et al., 1997). Hence, it is of great importance, to what extent such a "memory" of the ancient vegetation exists (Bakker et al., 1996b), and if it could act as a source of propagules in the restoration of fallow lands (Willems and Bik, 1998). However, most of the characteristic grassland species do not form persistent soil seed banks (Thompson and Grime, 1979; Graham and Hutchings, 1988a,b; Bakker et al., 1996a), and would, therefore, not survive cultivation periods. The restoration value of dry grassland seed banks is, therefore, very small (Dutoit and Alard, 1995; Bakker et al., 1996b). Hence, successful reestablishment of the target species depends on the function of dispersal vectors as for example sheep grazing (Marshall and Hopkinson, 1990; Fischer et al., 1996) since the species own dispersal capacities in space are very low (Poschlod et al., 1998). The introduction of sheep herding would also positively influence vegetation dynamics by limiting competition between stress tolerant target species and ruderal ancient weed species (Gibson and Brown, 1991), especially in those ecosystems where plant communities have been determined by sheep grazing for many centuries.

Though past agricultural land uses have affected the composition and structure of the dry herbaceous ecosystems throughout the landscape around the Mediterranean Sea (Grove and Rackham, 2001), effects of former ploughing on present day vegetation have received little attention in this region compared to northwestern Europe. Formerly ploughed sites are often difficult to locate because they are masked by the effects of a high number of wild fires, homogenising the vegetation during secondary succession following abandonment of cultivation (Trabaud and Galtie, 1996).

The Crau represents the last xeric steppe of southeastern France (Devaux et al., 1983) which has been shaped by sheep grazing for centuries (Rinschede, 1979; Fabre, 1998). The steppe vegetation represents a plant species association which is unique in Europe (Devaux et al., 1983). It provides a habitat for many endangered animal species, e.g. for the endemic grasshopper *Prionotropis hystrix rhodanica* (Foucart and Lecoq, 1998) and the rare bird species *Pterocles alchata* (sandgrouse; (Wolff, 1998). However, destruction by agricultural practices started in the 16th century, when irrigation systems were brought up and the northern parts were transformed into intensively used grasslands. At the beginning of the twentieth century, large parts of the dry semi-natural grasslands (called coussous) have been transformed into arable, industrial or military land, leading to the fragmentation of the former 60,000 ha steppe vegetation (Etienne et al., 1998). After abandonment of most arable fields in the 1980s, traditional transhumance has been reintroduced, connecting ex-cultivated fields with undisturbed steppe vegetation (Dureau and Bonnefon, 1998).

Hence, the aims of the current study were: (i) to describe the vegetation of coussous, ex-cultivated melon and ex-cultivated cereal fields and (ii) to investigate the impact of historical cereal and melon cultivation on the biotic and abiotic conditions of the ex-cultivated fields (e.g. species richness, evenness, soil chemistry, etc.) and (iii) to investigate the impact of historical cultivation on the seed bank of the steppe plant community, and its possible contribution for the restoration of the ex-cultivated fields. The general aim from a conservational point of view is, therefore, to find out if a re-development of the original coussous vegetation is possible on arable fields after abandonment.

2. Materials and methods

2.1. Study area

The study was carried out in the Crau, located about 50 km northwest of Marseille, France (Fig. 1). The plain is an old, stony river delta which was shaped by several changes of the Durance river bed between 650,000 and 120,000 years ago (Devaux et al., 1983). The dryness of the ecosystem is induced by the Mediterranean climate (mean temperature 14.5 °C, yearly precipitations of 500–600 mm; Cherel, 1988); precipitation does rarely occur within the vegetation period. Soil properties are exceptional: a water impermeable conglomerate in 40–60 cm depth (called locally "taparas") separates the ground water from the pebbly soil (Devaux et al., 1983).

While the steppe plant community of central Crau is determined by *Brachypodium retusum* (Poaceae), *Thymus vulgaris* (Lamiaceae) is the dominant plant species in the western regions (Loisel et al., 1990).

Between 1950 and 1960 relatively moderate cereal cultivation (without deep ploughing) and fertilisation took place (Devaux et al., 1983). Melon cultivation (1965 until now) was more intensive as it destroyed the "taparas" by deep ploughing, simplifying irrigation afterwards (Borck, 1998). Furthermore, huge amounts of fertilisers and pesticides were applied (Le Gloru, 1956). Before 1975, melon cultivation took place in small plastic tunnels (1.7 m width, 0.7 m height; Borrey, 1965). Afterwards, large plastic tunnels were used (3 m width, 2 m height), leaving always track ways of about 2 m between the tunnels. At most sites, cultivation stopped around 1990 because of melon overproduction, non-profitable cultivation and hard working conditions.

2.2. Study sites

As vegetation composition of central and western regions of the Crau is different, four study areas in