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20% loss of unimproved farmland in 22 years in the Engadin, Swiss Alps

Roman Graf, Mathis Müller, Pius Korner*, Markus Jenny, Lukas Jenni

Swiss Ornithological Institute, Seerose 1, 6204 Sempach, Switzerland

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ABSTRACT

Agricultural intensification has reached mountain areas with retardation. This development is worrying as it targets some of the last remaining strongholds of traditionally farmed land in central Europe which are important hotspots of biodiversity. However, large-scale documentations of changes in agricultural habitats are rare, but are needed to guide agricultural policy for the conservation of biodiversity.

We investigated vegetation changes of the agricultural landscape in a valley of the Alps (Engadin, a rather dry valley in Switzerland) between 1987/1988 and 2009/2010. In 58 plots (total area 1253 ha) we recorded changes in vegetation types and the intensity of usage and we investigated correlations between these changes and site factors.

By 2009/2010, all unimproved vegetation types have lost 20% of the area they covered in 1987/1988. The loss was greatest in areas where new agricultural infrastructure/reallocation projects ("ameliorations") had been realized. This observation illustrates the potentially devastating effect of such projects for farmland biodiversity.

Overall, intensively used fertile meadows (which are of limited nature value) have increased. The afflux came from the above mentioned unimproved grassland types, and not, as might be expected, from low-intensity fertile meadows (traditional hay meadows with a high nature value). In fact, the latter meadow type has seen a net gain from the intensively used fertile meadows (i.e. extensification). Both of these opposing processes (intensification and extensification) were subsidized by the government: money for infrastructure projects on the one hand and money for ecological compensation areas on the other hand.

Abandonment of farmland, unlike in some other regions in the Alps, is not a general problem in the Engadin, but it did reduce the area of xerotherm grassland by 19% and of nutrient-poor meadows by 8%. Grazing, which could prevent abandonment, increased during our study period, but was mostly of high intensity, thus was not optimal from a conservation point of view. Recent contracts for nature conservation are likely to help maintain mowing and extensive grazing management on marginal land.

The Engadin remains a biological hotspot and a beautiful landscape of high value for tourism. But these values are not secured as illustrated by the loss during the last 20 years. Thus, planers of irrigation and other infrastructure projects and decision-makers in general need to better incorporate both the extant nature values and their fragility into their planning.

1. Introduction

The agricultural ecosystem in many parts of the world has been revolutionized during the 20th century (Bignal and McCracken, 1996; Donald et al., 2006; Robinson and Sutherland, 2002). In central and western lowland Europe, vegetation types that formerly dominated large portions of the landscape are now shrunk to relicts, for example flower-rich mesotrophic grasslands (Fuller, 1987; Strijker, 2005; Wolkinger and Plank, 1981; in lowland Switzerland mainly *Arrhenatherum elatius* grassland, Stöcklin et al., 2007; Studer-Ehrensberger, 1995). These habitat changes are the result of agricultural intensification on productive sites and abandonment of marginal land driven by complex socio-economic factors (Robinson and Sutherland, 2002; Rutherford et al., 2008; Schneeberger, 2005) and technical progress, e.g. powerful machines, chemical fertilizers and biozides, irrigation, drainage, and land consolidation. At the global scale, these efforts have multiplied agricultural outputs (Matson et al., 1997), at the cost of a great loss of landscape diversity (Ewald and Klaus, 2009; Robinson and Sutherland, 2002) and farmland biodiversity (Benton et al., 2002; Donald et al., 2006; Green, 1990; Schifferli, 2000; Smart et al., 2005).

* Corresponding author. Tel.: +41 41 9804922; fax: +41 41 4629710.
E-mail addresses: roman.graf@vogelwarte.ch (R. Graf), mathis.mueller@vogelwarte.ch (M. Müller), pius.korner@bluewin.ch (P. Korner), markus.jenny@vogelwarte.ch (M. Jenny), lukas.jenni@vogelwarte.ch (L. Jenni).

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Agricultural intensification has strongly affected lowland farmland that is suitable for mechanized farming, but through technical developments (e.g. machines operating on steep slopes since the 1960s, Stöcklin et al., 2007, p. 33) the intensification has reached higher altitude mountainous farmland, too (Müller et al., 2005; Peter et al., 2008; Schneeberger, 2005). This development threatens some of the last remaining strongholds of traditionally farmed, unimproved land in central Europe (Bignal and McCracken, 1996; Riedl et al., 2012). Unimproved grassland is often species-rich (Billeter et al., 2008; Gough et al., 2000; Rudmann-Maurer et al., 2008; Wolkinger and Plank, 1981), and traditional alpine agro-environments are especially rich in biodiversity due to the heterogeneous abiotic factors (elevation, topography, soil, water availability, radiation; Väre et al., 2003). The conservation value of these mountain areas today is even more outstanding because of the advanced erosion of agricultural biodiversity in the lowlands. Nevertheless, important areas of high nature value farmland persist in the Alps (Kampmann et al., 2012; Schneider et al., 2012), harbouring a rich biodiversity that is also one of the attractions of summer tourism (Stöcklin et al., 2007).

Apart from intensification, abandonment of farmland is responsible for the loss of unimproved agricultural habitats in the Alps (Bignal and McCracken, 1996; Strijker, 2005). However, abandonment varies greatly among regions, depending on various factors such as the availability of governmental subsidies and off-farm jobs, on topography, and accessibility (Bender et al., 2005; Gellrich et al., 2007; MacDonald et al., 2000). While moderate levels of abandonment may increase biodiversity, especially at the landscape level (Zimmermann et al., 2010), advanced and large-scale abandonment threatens the persistence of species-rich habitats that depend on human utilization (Tappeiner et al., 1998).

Site factors have a strong influence on how farmland is used. Steep slopes and remote sites are often farmed less intensively (Kampmann et al., 2008; Rudmann-Maurer et al., 2008) and are more susceptible to being converted from mown meadows to pastures and from pastures to abandonment (Bender et al., 2005; Fischer and Wipf, 2002; Mottet et al., 2005; Reger et al., 2007; Tasser and Tappeiner, 2002). Intensification, on the other hand, is often observed in the vicinity of the farmstead and on flat land. Land reallocation and improved agricultural infrastructure are expected to have a strong influence on farmland management. In Switzerland, so-called "amelioration" projects bundle various measures from land reallocation to the construction of roads, farms and stables outside villages, drainage and irrigation systems with large financial support from the government (Swiss Federal Office for Agriculture, 2012, p. 188). Starting at the end of the 20th century, amelioration projects now claim to also observe ecological aspects in Switzerland (Lüscher et al., 1998) as well as in other countries (Vitikainen, 2004). Despite their enormous potential influence, the effect of amelioration projects on biodiversity has not received much attention in the scientific literature (Lisec and Pintar, 2005; Sklenicka et al., 2009; see Ewald and Klaus, 2009, regarding the effect of amelioration on the landscape in Switzerland).

In Switzerland, direct payments (subsidies) were introduced in 1993 to benefit ecology (Aviron et al., 2009). In 1999, principles for a sustainable ecological agriculture were anchored in the constitution, including regulations concerning balanced nutrient cycles and a minimum of 7% of ecological compensation areas (ECA). Today, essentially all farms in our study region, the Engadin in the Swiss Alps, comply with this environmental scheme. The percentage of ECA in the Alps in Switzerland is often much higher than the required minimum of 7% (Swiss Federal Office for Agriculture, 2012, p. 171) and can reach well over 40% (Kampmann and Herzog, 2006). In 2001 an additional quality scheme was introduced. Farmers get supplementary subsidies for ECA of high quality (SR-910.14, 2001), e.g. meadows with a defined minimal number of flowering plant species. In the mountains, this defined minimum quality is reached by 80% of the ECA (Riedl et al., 2012). Our study period with the two censuses in 1987/1988 and 2009/2010 spans across the time during which the ecological direct payments have been installed and thus documents the development during a sensible time period. Furthermore, it is noticeable that in the Engadin the majority of land is now organically farmed where chemical-synthetic fertilizers and biocides are not allowed: The proportion of organic farmland was below 2% in 1990, bounced up to 54% by 1996, and was around 70–80% since 2000 (stat-tab, www.pxweb.bfs.admin.ch).

We here present data documenting the changes in farmland vegetation types in the Engadin over 22 years, focussing on grassland below the timberline. We examined the influence of five site factors on the observed changes, which may help to identify relevant processes at work. While several studies report similar developments of the mountain agricultural habitats (see citations above), few have compared a sizable area (1253 ha in this study) at the level of vegetation types and over a time period of more than 20 years. We expected to find an increase of fertile grassland and of abandonment at the cost of unimproved grassland types, and an intensification of usage within fertile grassland. Regarding site factors, we expected a stronger intensification of plots close to the farms and of plots within an amelioration project, while abandonment was expected to correlate with steepness and remoteness.

2. Methods

2.1. Study area

The Engadin is an inner-alpine valley in southeastern Switzerland, stretching 80 km from southwest (upper end) to northeast (lower end at the border to Austria). The valley floor lies at 1000–1800 m a.s.l. and the tree line is at 2200–2300 m a.s.l. Typical for an inner-alpine valley the Engadin receives relatively little annual precipitation of about 700–1000 mm (www.meteoschweiz.ch).

Large parts of the agricultural land in the Engadin (below the timberline) are used as hay or, nowadays, silage meadows. Pastures make up about a quarter of the land (see Table 2). Formerly, small arable fields were an important landscape element in the Lower Engadin. However, between 1955 and 1975, 75% of the arable land was transformed mostly into grassland, and there was a further reduction from 91 ha in 1980 to 31 ha in 2010 (stat-tab, www.pxweb.bfs.admin.ch), a trend also observed in other alpine regions (Tasser et al., 2009). Some areas in the Engadin are highly structured with low hedgerows, groups of trees as well as patches of scree and xerotherm habitats. At other sites, large areas of meadows provide an open landscape. Apart from agricultural land covering 26% of our study region (Engadin below 2150 m a.s.l.) forests cover 56% and settlements 3%, the remaining 15% include lakes and scree. The scenic landscape and its rich biodiversity, together with an own cultural identity (e.g. typical houses), make the Engadin a unique environment with a high economic value for tourism.

While in some mountainous areas the human population decreases strongly (e.g. Bätzing, 2005; Mottet et al., 2005), this is not the case in the Engadin with its highly developed tourist industry. The human population was 20,233 in 1980 and increased to 25,129 in 2010 (Amt für Wirtschaft und Tourismus Graubünden). The construction of the Vereina railway tunnel in 1999 has greatly improved the year-round accessibility of the valley, favouring the further expansion of winter sport infrastructure. Distinct agricultural developments during the last few decades in the area include the spread of silage techniques, the widespread acquisition of modern machines, and in the Lower Engadin the construction of modern irrigation systems (traditional irrigation by affusion