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Dramatic decline in the Swiss arable flora since the 1920s

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ABSTRACT

Arable weeds are among those groups of plants that are most threatened in Europe due to management intensification and efficient cleaning of crop seeds in modern agriculture. Plant species loss in arable fields had been assessed in many European countries about 30 years ago, and has gained renewed interest during the last few years. A rich historical data set on plots where arable weeds had historically been recorded in Switzerland enabled the study of changes in arable weed species since the 1920s onward. In total, 232 locations with historical plots were revisited. There, we recorded all plant species and their abundances on 100m^2 plots. Across all plots the average number of species per plot declined dramatically by more than 60% during the last 90 years. Most species decreased in frequency, but common species stayed more frequent, while rare species – often characteristic weeds of traditionally managed crop fields – decreased in frequency or even disappeared. Plant groups with increasing species numbers and frequency were mostly neophytes, grasses and species with high nutrient demand. The above mentioned decline in species number and frequency of rare and characteristic weed species suggests that more effective conservation measures than hitherto taken are needed to ensure their preservation.

1. Introduction

Arable weeds are defined as plants that preferably grow in cultivated fields, but are not intentionally sown or planted. In Europe, arable weeds mainly evolved from Mediterranean species during the domestication and development of cereal crops during the last 5000 years (Holzner and Immonen, 1982). Weed species evolved functional traits that allow them to survive in the regularly disturbed habitats of arable fields (Scholz, 1996). The introduction of new crop species from the New World after 1496 led to an even richer arable flora as new weed species were introduced (Holzner and Immonen, 1982). However, during the last 100 years, rapid changes in agricultural practices had a major impact on the number and abundance of arable weeds. Today, farming practices in Europe are characterized by high input of fertilizers and pesticides (Herzog et al., 2006), which results in minimal intra-crop competition for nutrients and a reduction of weeds. Crop plants thus grow in higher densities and higher yields are achieved, but the accompanying arable weed flora is strongly and negatively affected (Robinson and Sutherland, 2002). Furthermore, crop seed cleaning has become more efficient, and seeds of arable weeds are thus no longer spread on fields *via* crop seeding (Van Elsen, 1994). In consequence, arable weeds species became rare and many are red listed all across Europe (Storkey et al., 2012). For instance, 137 out of 176 arable weeds are red-listed in Switzerland (Moser et al., 2002). Additionaly, a study in Oxfordshire/UK showed that weed species that had already been rare 40 years ago were mostly absent from arable fields today (Sutcliffe and Kay, 2000).

A meta-analysis of changes in the numbers of arable species across Europe showed on average a 20% reduction of species per field between 1939 and 2012 (Richner et al., 2014). However since the 1980s, the negative trend in the arable flora is believed to have slowed, stopped or even reversed due to the implementation of agri-environmental schemes that should benefit biodiversity, such as field strips or a generally lower input of fertilizers and lower use of pesticides (Decrem et al., 2007). Indeed, several recent studies from Europe suggested higher current species numbers in arable weeds than found in former surveys (e.g. Baessler and Klotz, 2006; Májeková et al., 2010 but see Fried et al., 2009; Meyer et al., 2013).

Every plant species has a unique set of traits. Changes in species composition of arable fields therefore also lead to changes in plant traits in arable weed communities (Violle et al., 2007; Navas, 2012). Plant traits typical of arable weeds of traditional fields are high

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seed longevity and short or even annual lifecycles (Thompson et al., 1998; Scholz, 1996). In contrast, contemporary arable fields are supposed to harbor many grasses, neophytes (introduced to Europe after 1496) and nitrophileous species, species that are ubiquitous or herbicide resistant and species that have even shorter life-cycles than the characteristic arable weeds of traditional fields (Otte et al., 2006; Fried et al., 2009). Therefore, the slow-down in species loss or even species gain recorded in several recent studies may be due to new species such as neophytes and pesticide-tolerant species, rather than an increase of characteristic (older) weed species (Otte et al., 2006). This change in diversity and composition of arable weed communities may also change the community plant trait spectrum, potentionally influencing ecosystem services provided by the biodiversity on arable fields (Franke et al., 2009). These services include e.g. food and shelter for beneficial organisms such as wild bees and ladybugs providing crop pollination and pest control (Isaacs et al., 2008) or protection from soil erosion (Pimentel et al., 1995). In addition, the recreational effect on people experiencing a colourful (weed-rich) arable landscape constitutes another ecosystem service of arable weeds (Junge et al., 2011).

In this study, we investigated changes in the species number and frequency of arable weeds, red listed species and characteristic arable plants by revisiting 232 locations where historical records on arable weeds had been taken in Switzerland. In addition, we investigated changes in plant traits of arable weed communities in time. Specifically, we asked the following two questions: (1) How did the species number and frequency of arable weed species change between historical and contemporary fields and (2) how did plant traits change over time?

2. Material and methods

2.1. Selection of historical plots and locations for re-survey

In order to test for changes in the flora of arable fields, we resurveyed 232 locations where plots recording arable weeds were made prior to 1990. The historical plots were obtained from a large vegetation database at Agroscope Reckenholz in Zurich. We selected historical plots and the related records of all occurring plant species of wheat, barley, beet or potato fields from studies conducted between 1927 and 1990. Other crop types were not taken into account as they are only rarely present in the historical surveys. We assigned these historical plots to the biogeographic regions of Switzerland delimited by Gonseth et al. (2001), i.e. Jura, JU; Swiss Plateau, ML; northern Alps, NA; southern Alps, SA; eastern central Alps, EZA and western central Alps, WZA. We also assessed whether the historical plots contained species that are currently red-listed in Switzerland (Moser et al., 2002). Subsequently, we took a stratified random sample of the whole dataset to obtain equal numbers of plots per (a) biogeographic region, (b) botanists of the historic plots (i.e. Volkart (1933), Buchli (1936), Salzmann (1939), Brun-Hool (1963) and Waldis (1986)), (c) red list status (i.e. a red listed plant species was present on the plot or not) and (d) crop type. We selected 700 locations. Locations that only showed grasslands on current aerial photographs (Swisstopo, 2010) were discarded. We revisited the sites of 515 historical plots

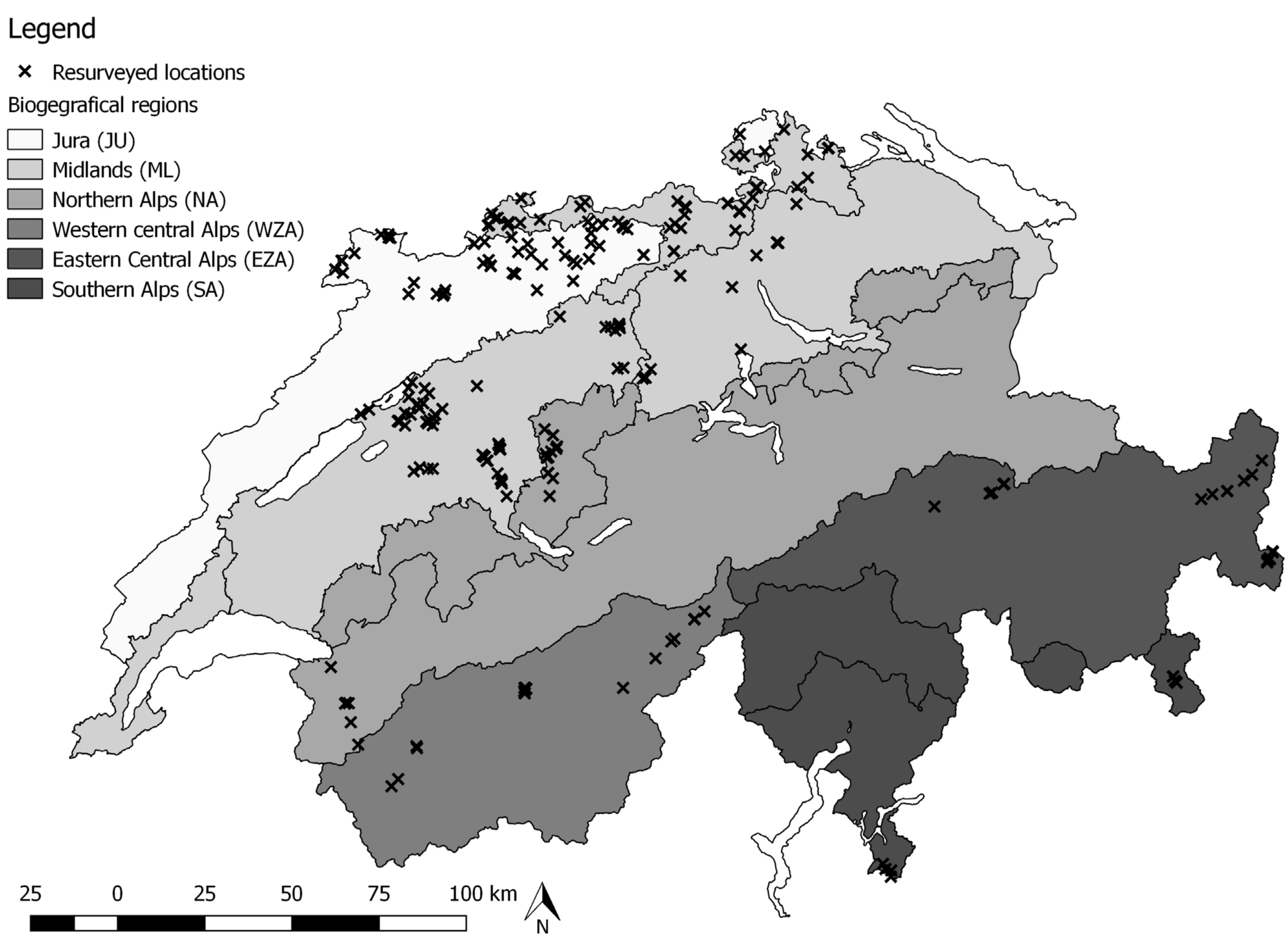

Fig. 1. Map of all revisited locations in Switzerland (n = 232).