Swiss alpine summer farming: current status and future development under climate change

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Abstract. High altitude grazing is widespread around the globe and also has a long tradition in European mountain regions. One-third of the Swiss farmland consists of summer pastures: seasonally used marginal pastures without permanent settlements, which extend between the grasslands and forests of permanent mountain settlements and unproductive mountain tops. Farmers’ main motivations for using those pastures have been and still are forage provision and health benefits for grazing animals, benefits for labour distribution between home farm and summer farm, and cultural ecosystem services such as the maintenance of a tradition and the associated lifestyle. Yet, remote pastures are being abandoned and are prone to reforestation, while more productive and accessible pastures are intensified. Those processes are related to changes in management practices, to scarcity of labour and – to a lesser extent – to climate change. We summarise the agronomic and ecological status of Swiss summer pastures, in particular with respect to livestock keeping, biodiversity and climate change, and speculate on future trends of summer farming.

Additional keywords: biodiversity, farmers’ perception, marginal grassland, rangeland, rough grazing, seasonal grazing, transhumance.

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Introduction

High altitude grasslands in mountain regions are often grazed only seasonally. Herders move up to these regions with their animals during the favourable season – usually the summer – to use the forage that is available for a short period of the year. Such so-called vertical transhumance systems are common across all major mountain regions in the world (Suttie and Reynolds 2003; Bunce \textit{et al.} 2004). In western, central, southern and northern Europe, more than four million hectares of grasslands are used through transhumance (Herzog \textit{et al.} 2005). These are mostly located across the Alpine Arc and the Massif Central, the Carpathians, the Apennines, the Balkan and Greek mountains and the Pyrenees. In the boreal zones, such as in Norway, transhumance also occurs in mountains with lower elevation (Austad \textit{et al.} 2004).

Transhumance links lowland and highland habitats. Together, they form two components of an integral system. Seasonally grazed mountain grasslands are among Europe’s most prominent High Nature Value farming systems (Oppermann \textit{et al.} 2012). Like many High Nature Value farming systems, however, seasonal mountain grazing is torn between abandonment and intensification. In the Atlantic mountains of the British Isles, for example, the tradition of seasonal grazing with migrating herds ceased 150 years ago (Jones and Wmffre 2004). Extensive mountain farming systems – like many rangeland systems – are threatened because they are relatively labour intensive but otherwise low input and low yielding, compared with other farming systems. Industrialisation of agriculture and globalisation require large quantities of standardised agricultural products, while seasonal summer farming yields smaller quantities of products with differing properties (e.g. cheeses of different types, consistency, taste, etc.). Still, they are often high-quality traditional specialties, linked to their geographical origin with, for example, a PDO (Product of Designated Origin) label. Also, many summer farming regions are, at the same time, attractive tourist destinations (Herzog and Schüepp 2013).

In Switzerland, the contrast between an industrialised society with a modern farming sector and the traditional summer mountain grazing practices is particularly striking. From most Swiss lowland cities, it takes less than 2 h to reach the summer farming region, where traditional, extensive herding is still practiced. In fact, 11% of the Swiss national territory (and one-third of its farmland) consists of summer pastures in the Alps and the Jura mountains. Despite their importance at the national scale for the farming sector, for mountain landscapes and related ecosystem services (e.g. biodiversity, soil protection), up-to date information on summer farming practices is limited. Research
and land use statistics of the last decade reveal that the abandonment of summer pastures is ongoing (Baur et al. 2007). At the same time, grassland utilisation tends to be intensified at locations, even within the mountain zone, where the natural conditions are favourable, and which farmers can easily reach with their herds (Kampmann et al. 2008). The most recent national evaluation was collated by Werthemann and Imboden (1982), based mainly on inventory data recorded from the 1950s onwards. There was thus uncertainty about the current situation of summer farming in Switzerland, and there were conflicting visions about its future development and the attitudes of stakeholders and policymakers towards it. We therefore initiated a national research program entitled, ‘AlpFUTUR – The future of Swiss summer pastures’ (Baur et al. 2007; Seidl et al. 2015; www.alpfutur.ch). In all, 80 researchers conducted 22 individual projects, which addressed agronomic, environmental, socioeconomic and technical issues related to summer farming (Lauber et al. 2013). This article summarises the agronomic and ecological findings of the AlpFUTUR program, whereas Seidl and Böni (I. Seidl, R. Böni, unpubl.) look at societal implications of summer farming and Schulz et al. (2018) present the implications for economic viability and government support.

**Status of summer farming in Switzerland**

About 7100 summer farmers manage 465 000 ha, grazed by 700 000 animals (mostly cattle and sheep), which correspond to 290 000 livestock units. In most locations, the summer grazing season lasts on average for ~100 days between mid-June and end of August. Summer pastures are an only seasonally used belt of marginal pastures without permanent settlements, extending between the grasslands and forests managed from permanent mountain settlements and the mountain tops consisting of mostly rock and ice (Figs 1 and 2). Since the Middle Ages, significant amounts of forest have been cleared and converted to rangelands and, as a consequence, in many regions the actual tree line is several hundred meters below the potential upper limit of forest growth (Szerencsits 2012).

Farmers started to use the summer pastures because the additional forage they provide allowed farmers to increase the size of their herds. This is still their most important motivation today, together with observed positive effects on animal health such as fertility and general fitness (Fig. 3). The third most important argument concerns the organisation of labour during the summer season. When employed herdsmen or family members take care of the animals on the summer farms, the workload on the home farm is reduced and labour is freed for making hay and silage. Farmers also value the pleasure that they gain from staying and working in the alpine environment and the tradition of summer farming as such. Additional arguments (not shown in Fig. 3) are concerned with the profitability (including subsidies) and the actual products obtained during the summering season (see Schulz et al. 2018).

![Summer pastures in the Swiss Jura Mountains and Alps according to altitude. Ninety-five per cent of the summer pastures are located between 1000 and 2500 m a.s.l.](https://example.com/fig1.png)
Major agronomic and ecological challenges

Abandonment, intensification and biodiversity

Mountain grasslands worldwide are known to be particularly rich in species (Klötzli et al. 2010; Spehn et al. 2010). They host specific plants and animals that are adapted to the often harsh environmental conditions; therefore, mountain grasslands are among the biodiversity hotspots of the world (Fischer et al. 2008; Peter et al. 2009). This is also true for the Swiss summer pastures, on which three-quarters of the country’s protected wetlands and dry meadows of national importance are located. Besides hosting 250 vascular plant species for which Switzerland has a specific responsibility, summer pastures host eight of the country’s 12 endemic vascular plant species (Lauber et al. 2013). At the landscape scale, the different characteristic grassland habitats that are laid out in the variable mountain topography and are interspersed with forest islets, form a
characteristic and attractive landscape, which is a major asset of the national tourist industry.

However, those areas are threatened by both abandonment and intensification. Abandonment of marginal grassland has occurred in most European mountain regions over the last decades (e.g. Pornaro et al. 2013). In Switzerland, regional policy and the financial support to agriculture through agri-environmental schemes have slowed this trend and contributed to maintaining traditional farming practices (Kampmann et al. 2012). Nevertheless, ~2400 ha of summer pastures are invaded by forest every year (Brändli 2012), amounting to a loss of almost 30,000 ha over the last 25 years (BFS 2013). Based on a spatially explicit model by Rutherford et al. (2008), we projected the future trend and evaluated its implications for species diversity (Schüpbach et al. 2012). The model predicts that abandonment and afforestation will be highest in the southern and central Alps (Fig. 4). The south-eastern Alps, in particular, have the highest importance for plant and animal species that depend on traditional, extensive summer pasturing (Walter et al. 2010).

A detailed analysis of two specific summer pastures, however, revealed that increased habitat heterogeneity because of shrub encroachment increased the number of species and the ecological quality of the pastures (Koch et al. 2015). Fig. 5 illustrates that the number of vascular plants is highest on summer pastures that are overgrown by 50% of Juniperus communis. Homburger et al. (2013) have also found the highest numbers of vascular plants on summer pastures grazed at medium levels of intensity. Those findings support the intermediate disturbance hypothesis (Horn 1975); similar curves have also been observed in European and American mountain grasslands (Cingolani et al. 2003; Spiegelberger et al. 2006; Olofsson and Shams 2007; see also Stohlgren et al. 1999). Higher numbers of species of vascular plants were consistent with higher arthropod diversity (grasshoppers, butterflies; Koch et al. 2013a). At yet higher levels of shrub

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**Fig. 4.** Projected loss of summer pastures by 2021 due to tree and shrub growth. (a) Total reforestation, (b) reforestation with closed forest, (c) reforestation with shrubs, and (d) reforestation with open forest. Source: Schüpbach et al. (2012).
cover, however, biodiversity declined, the spectrum of species changed and the species typical of summer pastures disappeared (Koch et al. 2015). Keeping the shrub cover low on marginal rangelands has always been a challenge. It requires careful herding management to maintain a certain grazing pressure (see also Babái et al. 2014; with an example from the Carpathians). In most cases, manual or mechanical removal of shrubs is also required. Keeping up this active maintenance of summer pastures has become more difficult during the last decades. The main reasons are that, in Switzerland, labour has become more expensive and the structural change in agriculture has led to bigger home farms managed by fewer people: the number of mountain home farms has decreased by 50% since the 1980s (BFS 2016). Both the trend and its origins are observed throughout European mountain regions (see MacDonald et al. 2000; and references therein). During summer, farm families are busy working the more fertile farmland and little time is left for maintaining remote, marginal rangelands. Among the summer pastures, farmers tend to intensify – if feasible – the more productive and easily accessible sections. This also entails a decrease in biodiversity. In order to counteract both trends – abandonment and intensification – a result-oriented agri-environmental scheme has recently been introduced. It grants payments for those sections of the summer pastures that maintain a minimum number of target plant species (Bundesrat 2016; see Schulz et al. 2018).

Livestock keeping: intensity and feeding strategy

One reason for the loss of pastureland is the slight but continuous decrease in summering animals over the last decades (Baur et al. 2007). In particular, the number of milk cows and heifers has been reduced, and suckler cows have only partly replaced them. Among other factors, this can be explained by the increased performance of modern cow breeds. In fact, high-yielding dairy cows require more energy intake at higher altitudes (Christen 1992; Imfeld-Müller 2013) and therefore suffer on summer farms from an energy deficit, which leads to reduced milk yield at the beginning of the summering season. Attempts to compensate for this deficit with cereal and protein supplements have been only partially successful. On an alpine pasture in Italy (1900 m a.s.l.), Bovolenta et al. (2009) supplemented the cow diet with 4.8 kg of organic matter per day, resulting in an increase in milk yield of only 0.9 kg day⁻¹. The supplements actually reduce the intake of grass and the net energy intake is increased only at higher levels of supplementation (Berry 2000). On Swiss alpine pastures, supplements are regulated and limited to 1 kg day⁻¹ per milk cow, mainly to limit nutrient imports to elevated mountain grasslands. High-yielding milk cows are less suitable for grazing steep and remote summer pastures, as already observed by Bovolenta et al. (1998), and often remain in the valley.

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**Table 1. Overview on major grazing systems practiced on summer farms**

Adapted from: Imfeld-Müller (2013)

<table>
<thead>
<tr>
<th>Grazing type</th>
<th>Advantages</th>
<th>Drawbacks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Free grazing</td>
<td>Low labour input</td>
<td>Heterogeneous utilisation of pasture (partly overgrazed, partly under grazed)</td>
</tr>
<tr>
<td>Extensively managed large paddock grazing</td>
<td>Animals can select the best fodder, relatively low labour input</td>
<td>Non-equilibrated utilisation of the pasture, important fodder losses (ungrazed parts)</td>
</tr>
<tr>
<td>Rotational grazing</td>
<td>Vegetation can re-grow between grazing periods; herd is easy to control</td>
<td>Irregular availability of fodder, relatively high labour input</td>
</tr>
<tr>
<td>Continuous herding</td>
<td>Regular and targeted utilisation of the pasture, continuous surveillance of animals protects them from large predators and other threats</td>
<td>Very high labour input</td>
</tr>
</tbody>
</table>
### Table 2. Summarised outcome of five qualitative interviews on effects of climate change and other direct drivers with experienced extension officers and summer farmers across the Swiss summer farm region

Adapted from: Blanke and Herzog (2012)

<table>
<thead>
<tr>
<th>Region</th>
<th>Central/Western Switzerland (Canton Berne)</th>
<th>Central Switzerland (Canton Obwalden)</th>
<th>South-eastern Alps (Canton Grisons)</th>
<th>South-western Alps (Canton Wallis)</th>
<th>Jura Mountains (Canton Vaud)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Region</strong></td>
<td>Central Switzerland (Canton Berne)</td>
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<td>South-western Alps (Canton Wallis)</td>
<td>Jura Mountains (Canton Vaud)</td>
</tr>
<tr>
<td><strong>Description of summer farming region</strong></td>
<td>Central Switzerland (Canton Berne)</td>
<td>Central Switzerland (Canton Obwalden)</td>
<td>South-eastern Alps (Canton Grisons)</td>
<td>South-western Alps (Canton Wallis)</td>
<td>Jura Mountains (Canton Vaud)</td>
</tr>
<tr>
<td>Average elevation of summer pastures [m a.s.l.]</td>
<td>1300–1900</td>
<td>1100–2300</td>
<td>1700–2600</td>
<td>1900–2400</td>
<td>1100–1400</td>
</tr>
<tr>
<td>Main animal categories</td>
<td>Milking cows, heifers</td>
<td>Milking cows, heifers</td>
<td>Heifers, milking cows, some goats</td>
<td>Milking cows, heifers, sheep</td>
<td>Milking cows, heifers</td>
</tr>
<tr>
<td>Management intensity</td>
<td>Average</td>
<td>Average (low on alps with moist pastures)</td>
<td>Low and declining</td>
<td>Low and declining</td>
<td>High</td>
</tr>
<tr>
<td>Interview partners</td>
<td>Extension officer, 40 years of experience</td>
<td>Extension officer, 30 years of experience</td>
<td>Extension officer and three farmers, 40 years of experience</td>
<td>Extension officer, 30 years of experience</td>
<td>Extension officer and three farmers, 50 years of experience</td>
</tr>
<tr>
<td>Climate change effects observed</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Beginning and duration of summering period</td>
<td>Tends to start ~5 days earlier. Earlier start of vegetation period and need to use young grass with higher quality</td>
<td>About a week earlier. Earlier start of vegetation period and less risky because the better road system allows to evacuate the cattle in case of late snowfall</td>
<td>Constant, no trend perceived</td>
<td>Slightly longer, mostly because of declining stocking rate. Start date mostly determined by traditions and customs</td>
<td>Earlier and up to 3 weeks longer. Need to use young grass with higher quality for high-yielding milk cows</td>
</tr>
<tr>
<td>Fodder quality and availability</td>
<td>Increased quality and quantity due to improved management and fertilisation. Increase of problematic weeds</td>
<td>Increased quality due to improved management and in spite of reduced fertilisation. Increase of problematic weeds</td>
<td>On well managed pastures: increased quantity observed. On underused pastures: increased biomass with low fodder quality</td>
<td>Reduced fodder availability on lower and south exposed pastures due to lack of water in spring. Increase of problematic weeds</td>
<td>Observed trend of reduced fodder quantity and quality due to reduced fertilisation. Increase of problematic weeds</td>
</tr>
<tr>
<td>Shrub and forest growth</td>
<td>Constant pressure, but increasingly by deciduous trees. Increased pressure by shrubs above the timber line</td>
<td>Loss of marginal pastures due to lack of management and possibly to longer duration of vegetation period</td>
<td>Faster growth of shrubs and trees even under constant management. Perceived increase of tree line</td>
<td>Increase of tree line, possibly due to warmer temperatures. Loss of pastures due to lack of management and to reduced grazing pressure</td>
<td>In last decades, woody pastures have turned into wood because of forest protection. Recently they have been cleared again</td>
</tr>
</tbody>
</table>
Increased intensity of rainfall events. In some years, Swiss alpine summer farming may become a limiting factor due to insufficient water capture because of more frequent extreme rainfall. Local topography and pastures are dry already in spring because snow evaporates without melting. Animals need more drinking water during heat periods in summer. Increasing lack of water for watering livestock, milk processing, personnel due to both, increased requirements and insufficient water capture because of more frequent extreme rainfall causing landslides, at higher elevations due to melting of permafrost. Animals need more water availability. Enough water, no trend is partly caused by increased requirement for cheese making and conservation. New wells have been dug. Increasing extreme of drought and of heavy rain. More thunderstorms appear in spring since 1980s. But still enough water available throughout the season. Increase of drought and of heavy rain. More landslides, at higher elevations due to melting of permafrost. Some new irrigations have been installed. Increasing lack of water for watering livestock, milk processing, personnel due to both, increased requirements and insufficient water capture because of more frequent extreme rainfall causing landslides, at higher elevations due to melting of permafrost. Animals need more drinking water during heat periods in summer.

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Aquaculture and livestock management strategies. Livestock keeping: grazing management strategies. Water availability. Enough water, no trend. Water availability. Enough water, no trend. Trend towards less water for cheese making and conservation. New wells have been dug. Meadows and pastures have traditionally been irrigated. Some new irrigations have been installed. Increasing lack of water for watering livestock, milk processing, personnel due to both, increased requirements and insufficient water capture because of more frequent extreme rainfall causing landslides, at higher elevations due to melting of permafrost. Some new irrigations have been installed.

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Table 3. Conceptual approach to factors that act in favour of either intensification or extensification/abandonment of summer pastures in Switzerland

<table>
<thead>
<tr>
<th>Environmental conditions</th>
<th>Intensification</th>
<th>Extensification/abandonment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Topography and location</td>
<td>Flat areas at lower altitude, close to the summer farm</td>
<td>Steep pastures, remote and difficult access, poor soil conditions and risk of stone fall and loss of animals</td>
</tr>
<tr>
<td>Climate change</td>
<td>Increased productivity of the sward and longer summer farming period</td>
<td>Regionally longer drought periods and more frequent and violent thunderstorms</td>
</tr>
<tr>
<td>Agronomic and technological progress</td>
<td>Higher yielding animals require forage of higher quality and protein content</td>
<td>High-yielding animals are not adapted to graze high altitude, remote pastures of low forage quality</td>
</tr>
<tr>
<td>Husbandry animal breeding</td>
<td>Mobile phones, GPS trackers, virtual fences, etc. may facilitate herding. This may help to prevent abandonment but should not lead to intensification</td>
<td>Scarcity of labour and increased availability of fodder at the home farm</td>
</tr>
<tr>
<td>Socioeconomic developments</td>
<td>Subsidies aim at maintaining the current status of summerfarming and at increasing the ecological quality of pastures. They aim at preventing both, abandonment and intensification</td>
<td>Good marketing opportunities for high quality cheese</td>
</tr>
</tbody>
</table>

valleys. In order to obtain a more differentiated picture of the consequences of climate change, we interviewed experienced practitioners and agricultural extension agents from major regions in the Alps and the Jura mountains. We opted for a qualitative approach, in contrast to survey techniques (e.g. Nunoo and Akua Asiamah Nunoo 2016). We asked them whether they had perceived climatic trends over the last decades, what the consequences for summer farming were until now and what they possibly expected for the future. Their responses are summarised in Table 2.

It is evident that the results of such qualitative interviews have to be interpreted with caution. The farmers and extension officers themselves underlined that their evaluations may be affected by subjective perceptions. Yet, their responses are fairly consistent and can be summarised as follows:

– Over the last decades, the summer farming season has started earlier in the spring (by about a week). It also tends to last longer, but its duration is limited by the availability of forage.

– The overall productivity of summer pastures has increased, allowing for longer and/or more intensive pasturing. This can be due to both climate change and agronomic measures (fertilisation with organic manure, improved pasture management), and the effects of changing climate and land-use practices cannot be disentangled.

– Shrubs and trees also seem to grow more vigorously and the encroachment of marginal summer pastures by woody species appears to happen more rapidly.

– Water scarcity during the summering period has always been a limiting factor in the Jura Mountains and in the south-western and south-eastern Alps. In those regions, water scarcity has worsened during the last decades. Effects of water scarcity vary strongly at the small scale and depend on local elevation and exposition. This offers the opportunity to move animals from drier pastures to pastures where forage is still growing. Pipelines are being built to transport water to summer farms that regularly suffer from lack of water.

Some of those observations are confirmed by measured time series such as the decrease in snowfall since the 1980s (Laternser and Schneebeli 2003), earlier start of the vegetation period along with higher biomass production (OcCC 2007; Jonas et al. 2008; Rammig et al. 2010), a trend for the tree line to shift to higher altitudes (Gehrig-Fasel et al. 2007) and longer dry periods in the Jura mountains (Buttler et al. 2012).

At the large (regional) scale, summer pastures may become more important in years when forage growth is inhibited in the lowlands because of summer dryness. Grazing animals may then be moved to higher altitudes, including summer pastures, where there is still comparatively higher precipitation and more forage available. More flexible stocking strategies are recommended and observed as a strategy to adapt to climate change also in North America and South Africa (e.g. Derner et al. 2016; Samuels et al. 2016).

Conclusions and recommendations

Table 3 proposes a conceptual approach to factors that favour either intensification or extensification/abandonment of summer farming in Switzerland. Yet, summer farming is a tradition that farmers and policymakers want to maintain, despite its dependence on public support through subsidies. The major justification for those subsidies are the ecosystem services they help maintaining, namely the production of forage, biodiversity, landscape scenery and cultural values. Specific agri-environmental schemes targeting those services have recently been put in place by the government, in line with the recommendation resulting from the AlpFUTUR program (Schulz et al. 2018). Payments for summer-pasture biodiversity are result-oriented, which should increase the motivation of summer farmers to maintain species-rich pastures. To this end,
shrub encroachment and reforestation need to be controlled by combinations of manual labour and careful and targeted pasture management, which may also involve combinations of different animal species (Koch et al. 2013b). Best management practices are illustrated by three short AlpFUTUR films, in which summer farmers explain their herding strategies (Fry 2013; Herzog et al. 2016). Deliberate abandonment of remote or particularly steep or exposed sections, possibly even with targeted reforestation, will reduce the workload for summer farmers and may also reduce injuries and losses of grazing animals at sometimes hazardous locations.

Under climate change, forage production even on marginal summer pastures may gain importance. Although they will also be affected by reduced summer precipitation and higher temperatures, effects are expected to be less at high elevations compared with the lowlands. Because the topography is highly variable, many summer farms have pastures with differing exposures, and north-exposed pastures will be less affected by summer drought. This may lead to a renewed reliance of farmers on mountain summer pastures for forage production.

**Conflicts of interest**
The authors declare no conflicts of interest.

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