Effects of innovative management options on perennial grassland in the mountain area of Switzerland

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Abstract
Based on a Delphi study, six innovative management options were assessed with regard to their feasibility and potential effects on the delivery of ecosystem services (ES) for the Swiss alpine region: (1) Complete sward renewal through sward destruction and reseeding, (2) Virtual fencing, (3) Overseeding with different grass or legume species or mixtures without complete sward destruction, (4) Practical use of rising plate meter for yield estimation, (5) Biodiversity management, (6) Weather and grass growth monitoring to improve grassland management. We found that sward renewal has negative effects on biodiversity, carbon storage, flood control, prevention of soil erosion and prevention of loss of organic matter and therefore should not be applied in the Swiss alpine regions. Rising plate meters and grass monitoring have a positive effect on grass production without any negative consequences on other ES. Biodiversity management fits perfectly under the Swiss alpine conditions, in particular when farmers are compensated for their economic loss.

Keywords: Delphi-study, Sward manipulation, Grazing management, Farm-scale management, Monitoring grass growth

Introduction

Grasslands provide a wide range of ecosystem services (ES) (Bengtsson et al., 2019; Zhao et al., 2020) including provisioning services such as forage production, regulating and supporting services such as soil carbon storage, erosion control or pollination and cultural services (Huber et al. 2020). Climate change and changes in land use intensities affect the functioning of ecosystems and thus the delivery of ES. In Swiss alpine regions, the delivery of ES are simultaneously affected by land abandonment (Gellrich et al., 2007), increasing land use intensity and climate change. Expert knowledge from researchers and practitioners is needed to develop management options that support the delivery of ES of permanent grasslands under current and changing conditions. Various innovative management options for perennial grassland have been developed, but if and how these support the delivery of ES in alpine regions is not well understood. We identified six management options that might be applicable in the alpine region (Table 1). A Delphi study was conducted to assess the feasibility and potential effects of these new management options on the delivery of ES under the specific climatic, political and institutional conditions of the Swiss alpine region.

Table 1: Description of management options

Type	Option	Description
Sward manipulation	Overseeding	Overseeding is carried out on the existing sward to create establishment niches in which a selection of desired plant species can be broadcast sown or slot seeded with different grass or legume species or mixtures without complete sward destruction.
	Sward renewal	Complete sward renewal through sward destruction (non-selective herbicide spraying or cultivation) and reseeding; carried out when the existing sward is not meeting current land management objectives, e.g. when the current sward contains less than 50% desired species.

Monitoring & predicting grass growth	'GrassCheck'	Weather and grass growth monitoring to improve grassland management and to assist farmers in improving both grass growth and utilisation. It can include an online management platform to monitor and predict grass growth, grass quality and weather in different regions.
	Rising plate meters	Rising plate meters are used to measure grass sward height as a proxy for grass quantity. A large number of measurements can be taken in a short time so that a large area can be covered to account for spatial heterogeneity within fields.
Grazing management	Virtual fencing	Use of virtual fencing technologies to control and manage grazing without installing permanent barriers or the need for high labour input temporary (electric) fencing.
Farm-scale management	Biodiversity management	Managing grassland in a variety of ways across a farm to create a diversity of habitats and enhance biodiversity at various trophic levels from soil invertebrates to birds and mammals.

Materials and methods

An online Delphi study, using two rounds of questionnaires with anonymous feedback of results between rounds, was carried out with ten experts who assessed the six management options in terms of the delivery of ES and their applicability under both the current climatic conditions in the alpine region, and the socio-economic, institutional and political conditions of Switzerland. The six management options were pre-selected by experts for their representation of a range of 1. technology readiness levels; 2. level of new skills required for implementation; and 3. potential impact in the alpine region. Ten expert participants for the Delphi study were recruited from 4 institutions in Switzerland, representing a range of academic disciplines (economist, farm advisor, ecologist, soil scientist, livestock scientist, engineering and precision farming, veterinary scientist, animal welfare, social scientist). Experts were selected for their subject knowledge as well as contextual knowledge of Swiss alpine regions. We do not have a spatial distribution in the observations because experts were only selected based on their expertise.

A modified Delphi technique (Hasson and Keeney, 2011) was used to explore the attitudes of the interdisciplinary group of experts and gather information and opinions in order to obtain the most reliable position of the group (Dalkey & Helmer 1963). An online survey platform was used to create two rounds of the survey. Each round consisted of closed questions, answered using likert scales, and open questions, using free text, allowing for elaboration and explanation. The first round questions focused on the assessment of each management option in relation to its rationale, mechanism of action and outcomes, ecosystem service delivery, applicability and support. The second round presented anonymised summaries of the results of the first round, highlighting agreement and disagreement, and asked participants to answer questions again for which there had been less than 80% agreement. This sought to offer experts the opportunity to clarify or change their opinions based on the answers of the other experts.

The two rounds took place in September and October 2020, with each round's online survey open for participation during a 1.5 week period, with a break of 2 weeks in which the results of the first round were summarized for participants in the second round. Quantitative and qualitative data from the surveys were analysed using software packages SPSS and NVivo for trends and comparisons.

Results and discussion

The majority of the experts (based on second round survey, where in total 9 experts participated) stated that the following four out of six management options are successfully applicable under both, the current climatic conditions in the alpine region and the socio-economic, institutional and political conditions of Switzerland: Overseeding, GrassCheck, rising plate meters, and biodiversity management. Only one expert disagreed that rising plate meters are applicable in the alpine region arguing that this option can only be implemented if the relationship between sward height and biomass is properly calibrated, a too time-consuming task in the case of diverse alpine grassland regions. There was no consensus on whether sward renewal and virtual fencing are successfully applicable

under the current climatic conditions of the alpine regions. One expert stated that sward renewal increases the risks of erosion and doubted that seeds adapted to the specific climatic conditions would be available. Virtual fencing is considered problematic in the alpine regions because of inaccurate georeferencing due to steep slopes.
Experts achieved a consensus that sward renewal and virtual fencing were not successfully applicable under the current political, institutional and socio-economic conditions of Switzerland. For virtual fencing, the current Swiss animal welfare legislation does not allow animals to receive electric pulses and citizens' acceptance of virtual fencing was likely to be low. For sward renewal, one expert stated that destroying swards in alpine regions was not accepted by Swiss society. However, the majority of the experts saw some potential relevance for all six management options if the climatic conditions in Swiss mountain regions were to change.
The Delphi-study showed that farm scale and sward manipulation measures such as biodiversity management, overseeding, and sward renewal affect all of the considered ES. The majority of experts stated that biodiversity management measures have a positive effect on biodiversity and pollination. Overseeding was also rated positively for biodiversity and prevention of soil erosion, while sward renewal was rated negatively for five out of nine ES (Table 2). While biodiversity management was rated positively in terms of cultural ES such as landscape aesthetics and recreation it was rated negatively for provisioning ES such as grass production for livestock and biomass. In contrast, the majority of experts stated that both overseeding and sward renewal have a positive effect on provisioning ES. The results of the Delphi study showed that measures for monitoring or predicting grass growth such as GrassCheck and rising plate meters neither have a positive nor a negative effect on most of the ES. However, both measures were rated positively in terms of animal health and animal welfare, and grass production for livestock and biomass. The majority of the experts considered that virtual fencing would have no effect on other than provisioning ES. While experts reached no consensus on whether it is positive or negative for animal health and animal welfare, the majority rated it positively in terms of cultural ES such as recreation.

Table 2: Effects that each management option is likely to have on delivery of ES

	Biodiversity Management	Over-seeding	Sward renewal	Grass-Check	Rising plate meters	Virtual fencing
Biodiversity	+	+	-	+/-	+/-	n.c.
Pollination	+	n.c.	n.c	+/-	+/-	+/-
Carbon storage	+/-	n.c.	-	+/-	+/-	+/-
Greenhouse gas emmissions	n.c.	+/-	n.c	+/-	+/-	+/-
Flood control	+/-	+/-	-	+/-	+/-	+/-
Water quality	+/-	+/-	+/-	+/-	+/-	+/-
Prevention of soil erosion	+/-	+	-	+/-	+/-	+/-
Prevention of soil compaction	+/-	+/-	n.c	+/-	+/-	n.c.
Prevention of loss of organic soil matter	+/-	n.c.	-	+/-	+/-	+/-
Landscape aesthetics	+	+/-	n.c	+/-	+/-	n.c.
Recreation	+	n.c.	n.c	+/-	+/-	+
Animal health and welfare	n.c.	+/-	+/-	+	+	n.c.
Grass production for livestock	-	+	+	+	+	n.c.
Grass production for biomass	-	+	+	+	+	+/-

\+ More than 50% of the experts stated that the management option is likely to have a positive effect
+/- More than 50 % of the experts stated that the management option is likely to have neither a positive nor a negative effect
\- More than 50 % of the experts stated that the management option is likely to have a negative effect
n.c.: experts achieved no consensus.

Conclusions and recommendations

Sward renewal should not be applied under the current climatic, political, institutional and socio-economic conditions of the Swiss alpine regions because of its foreseeable negative ecological consequences. Biodiversity management fits perfectly under the Swiss alpine conditions, in particular when farmers are compensated for the economic losses. For management options that focus on the monitoring and prediction of grass growth we found no trade-off between the different ES that could be delivered. They are recommended because of their positive impacts on provisioning services such as grass growth for livestock and biomass without any foreseeable negative consequences on biodiversity. However, virtual fencing is currently not applicable in Switzerland because of animal welfare concerns.

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