Surrogate taxa and impact factors for plants and insects on Swiss summer pastures

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Summary

Summer pastures in the Swiss Alps have been shaped by human agricultural activities over centuries, leading to grassland areas which are very rich in biological diversity. However, land-use changes driven by changing social and economic needs are now threatening this biodiversity: management is intensified in easily accessible and productive areas, whereas remote areas remain underused, or are abandoned. The development of management recommendations and measures to conserve biodiversity requires a better understanding of the interactions of species diversity and the environment. The investigation of both plant and invertebrate taxa permits the integration of their requirements. In light of current political dialogue which supports efforts to conserve biodiversity in summer pastures in Switzerland, this PhD aims to provide baselines for future improvement of agricultural measures.

Although summer pastures make up one third of the whole Swiss agricultural area, direct payments dedicated to support its management are very low, and current political instruments do not support sufficiently efforts to conserve biodiversity. However, a vegetation-based approach, such as the one implemented in the permanently utilized agricultural area, is currently under discussion. But studies to date, which evaluate the indicator value of vascular plants for other taxa, yielded inconsistent results and investigations in alpine habitats are rare. The extent to which vascular plants are adequate surrogates for insect groups, as represented by butterfly and grasshopper diversity, was investigated by examining the congruence of species richness and community similarity patterns on two subalpine pastures. It could be shown that the diversity of vascular plants coincided well with the diversity of butterflies and grasshoppers, in particular when community diversity measures instead of simple species richness were used. The findings indicate that conservation measures intended for vascular plant conservation are also likely to benefit the insect groups.

Shrub encroachment, the spread of shrubs into grassland, has become a major issue for many mountainous regions in Europe. In Switzerland, forest cover has increased by one-third during the past few centuries, with the majority occurring in summer pasture habitat. The transformation of grassland into woodland affects many ecosystem services including biodiversity. In order to determine the impact of encroachment by dwarf shrubs on species diversity, the effect of shrub cover on the species composition of vascular plants, butterflies and grasshoppers was examined. In a vegetation gradient representing successional stages of encroachment, vascular plants and grasshoppers showed preferences for different early to intermediate stages of succession. Instead, butterflies showed no clear response to the gradient in shrub cover. The results also showed that the effects of biotic factors (shrub cover, grazing intensity and variables related to vegetation for the
insect groups) on species composition of all three taxa was generally greater than that of large-scale abiotic factors (altitude, aspect and slope), suggesting a major impact of land-use changes on biodiversity. We recommend management actions which avoid extensive encroachment by dwarf-shrubs but promote a mosaic of patches at different successional stages.

Traditional management and long-term grazing have been repeatedly recommended for the preservation of the summer pasture habitat and its biodiversity. The lack or inappropriateness of livestock management have been cited as main reasons for the spread of shrubs into grassland. Indeed, the negative relationship found in this study between cover of dwarf shrubs and management intensity suggests that sufficient grazing pressure is needed to counter shrub encroachment. Shrubs were absent from heavily grazed areas, whereas areas rarely visited by animals tended to be highly encroached. Plant species richness was highest in areas with intermediate shrub cover where a grass-shrub mosaic is formed. Shrubs were found to serve as refuges for grazing- and trampling-intolerant species. However, areas with high dwarf shrub cover were generally species poor. Butterfly and grasshoppers species richness instead, was mainly related to botanical diversity. An intermediate grazing intensity evenly distributed over the whole pasture prevents localized overexploitation or underuse and is important for biodiversity conservation. An adequate grazing pressure has the potential to control the spread of dwarf shrubs, but facilitate the presence of single shrub islands thus protecting more sensitive plants and insects from intensive grazing.

Strong heterogeneities in the management of summer pastures can have important consequences for biodiversity. The feeding and dunging activities of grazing animals play a crucial role in the distribution of soil nutrients and vegetation. To gain a better understanding of the influence of dairy cattle activity upon nutrient patterns, a model for the distribution of phosphorous (P) on a subalpine pasture used by dairy cattle was developed. The results show that only 2% of the pasture area gained >0.5 kg P ha\(^{-1}\) year\(^{-1}\) whereas 10% lost >0.5 kg P ha\(^{-1}\) year\(^{-1}\). These zones of highest P accumulation and depletion were mainly concentrated in the flat areas around the stable building. The continuous removal of nutrients due to milk production, accounting for 40% of consumed P, induced consistent nutrient losses from these areas. In contrast, two-thirds of the pasture consisting of nutrient-poor vegetation dominated by *Nardus stricta* and dwarf shrubs was poorly used by cattle. The degraded state of a large proportion of the pasture suggests that the current patterns of cattle activity have been repeated over long periods of time. In order to stop further degradation, management actions such as fencing, rotational grazing or strategic placement of water and mineral mix supplements that prevent a strong bias in the use of the pasture are recommended.
Zusammenfassung


Sukzession. Tagfalter zeigten bezüglich des Strauchdeckungsgradienten keine klare Präferenz. Die Resultate zeigten auch, dass der Einfluss von biotischen Faktoren (Strauchdeckung, Beweidungsintensität, sowie Vegetationsvariablen für die Insektengruppen) auf die Artenzusammensetzung aller drei Organismengruppen generell grösser war als derjenige von grossräumigen abiotischen Faktoren (Höhenlage, Exposition und Neigung). Dies weist darauf hin, dass Veränderungen in der Landnutzung eine bedeutende Wirkung auf die Artenvielfalt haben.


Eine sehr heterogene Bewirtschaftung der Alpweiden kann negative Folgen für die Artenvielfalt haben. Die Frass- und Ausscheidungsaktivitäten von Weidetieren spielen eine entscheidende Rolle in der Verteilung von Bodennährstoffen und Vegetation. Um ein besseres Verständnis zum Einflusses von Milchkuhaktivitäten auf das Nährstoffmuster zu haben, wurde ein Modell für die Verteilung von Phosphor (P) durch Milchkühe auf einer subalpine Weide entwickelt. Die Resultate zeigten, dass nur 2% der Weidefläche mehr als 0.5 kg P pro ha und Jahr gewonnen, während 10% mehr als 0.5 kg P pro ha und Jahr verloren hat. Diese Zonen mit den höchsten P-Anreicherungen und -Verlusten, waren hauptsächlich auf die ebene Flächen in der Nähe der Alpgebäude konzentriert. Der andauernde Entzug von Nährstoffen durch die Milchproduktion (40% des aufgenommenen P) führte zu hohen Nährstoffverlusten aus diesen Flächen. Im Gegensatz dazu wurden zwei Drittel der Weidefläche, die aus nährstoffarmer, Borstgras und Zwergsträucher dominiert der Vegetation
bestand, von den Tieren wenig genutzt. Der degradierte Zustand eines grossen Teils der Alpweide deutet darauf hin, dass das gegenwärtige Beweidungsmuster über eine lange Zeitperiode wiederholt wurde. Um eine weitere Degradierung der Alp zu vermeiden, werden Bewirtschaftungsmassnahmen empfohlen, die eine stark unterschiedliche Nutzung der Weide verhindern, wie zum Beispiel das Auszäunen oder die strategische Platzierung von Wasser und Futterergänzungen.