Using yellowness in drone-based RGB images to map buttercup cover in an upland pasture

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Abstract

The reduction of unwanted plant species in pastures is a persistent objective of grassland management. Evaluating different management options requires the assessment of the spatial coverage of the unwanted species. Here, we evaluate the use of drone-based images to quantify the cover of buttercup (*Ranunculus acris*) in an upland pasture (1654 m asl.) in the Central Swiss Alps. Buttercup is of primary concern because it is moderately toxic and avoided by grazers. Between 2016 and 2020, we conducted a randomized complete block trial with ten different treatments (combinations of grazing, mowing, liming, herbicide and overseeding) in four repetitions. Aerial images were taken annually at the peak of buttercup flowering, with a fixed-wing autonomous drone (senseFly eBee) carrying an RGB camera (Canon S110 and from 2019, senseFly S.O.D.A.) and post-processed using Pix4Dmapper. Yellowness was calculated as the percentage of yellow pixels using optimized thresholds on the RGB channels. The correlation coefficient between the yellowness of the images and the share of buttercup estimated by an independent observer was above 0.85 for the last two years. The newer S.O.D.A. camera outperformed the S110 due to its higher resolution, which was shown to be crucial for this kind of assessments.

Keywords: subalpine pasture, weed cover, drone, RGB images

Introduction

Around one third of the agricultural land in Switzerland is located near or above the alpine treeline and only used during summer (Lüscher *et al.*, 2019). It is grazed by ruminant livestock and characterised by shallow soils and undulating topography. Since there are fewer management options available in a pure grazing system than in mixed mowing-with-grazing, and since the harsh climate limits the growth of productive grasses, sward composition is often of primary concern. Buttercup (*Ranunculus acris*) is a common forb in many pastures that are fertilized with livestock manure. It produces the glycoside ranunculin which causes mouth blistering, intestinal disorder and potentially respiratory failure (Lamoureaux and Bourdôt, 2007). It is therefore avoided by grazing livestock and has a competitive advantage over more palatable species. Hence, buttercup can reach substantial cover in grazed pastures, thereby decreasing forage quality and usage. However, adequate regulation strategies to reduce its abundance are lacking. Since the assessment of species cover over large areas is labour-consuming, we tested whether remote sensing can help to monitor the effects of regulation strategies already developed for invasive grasses and large-leaved forbs in grassland (see for example Malmstrom *et al.*, 2017 and Lam *et al.*, 2020).

Materials and methods

From 2016 to 2020, a field experiment was conducted on a summer pasture in the Meien valley in the Central Swiss Alps (46°44′30.1″ N, 8°29′14.8″ E) at 1654 m asl. The site is a slightly undulating valley bottom formed by the sedimented gravel of the river Meienreuss and covered by only 5-10 cm of organic topsoil. The pasture is grazed by dairy cows twice during summer in a rotational grazing systems. The sward is dominated by grasses (50-70% cover, mainly *Agrostis capillaris*, *Festuca rubra* and *Phleum rhaeticum*), buttercup (10-45%), and other forbs (10-25%, mainly *Alchemilla vulgaris*). Ten treatments were applied on subplots of 40 m^2 in a randomized block design with four repetitions. Aerial images were taken annually at the peak of buttercup flowering, using a fixed-wing autonomous drone (eBee, senseFly, Cheseaux-sur-Lausanne, Switzerland) flying around 50 m above ground and carrying an RGB camera. Initially, a Canon S110 with 12.1 MPixels was used, which had to be replaced by a newer senseFly S.O.D.A. with 20 MPixels in 2019. The images were merged using Pix4Dmapper (Pix4D SA, Prilly, Switzerland) to a resolution of 2 cm and geolocated using ground control points. The yellowness in all images was derived using threshold values of >167.9 for red, >170.7 for green and <86.4 for blue. These values were obtained by optimizing the average correlation coefficient over all five years. The obtained values were compared to estimates of buttercup cover on the ground made by a single observer every year.

Results and discussion

Image quality differed between years with lowest quality in 2017 and 2018 and the best in 2019 and 2020. As examples, the data of 2018 and 2020 are shown in Figure 1. In 2018 the timing of the capture was not optimal right after the mowing. In addition, the Canon camera used in that year produced relatively blurred images. In 2020, the area was captured in full bloom and with the newer S.O.D.A. camera. This resulted in much more detectable yellowness in 2020 than in 2018.

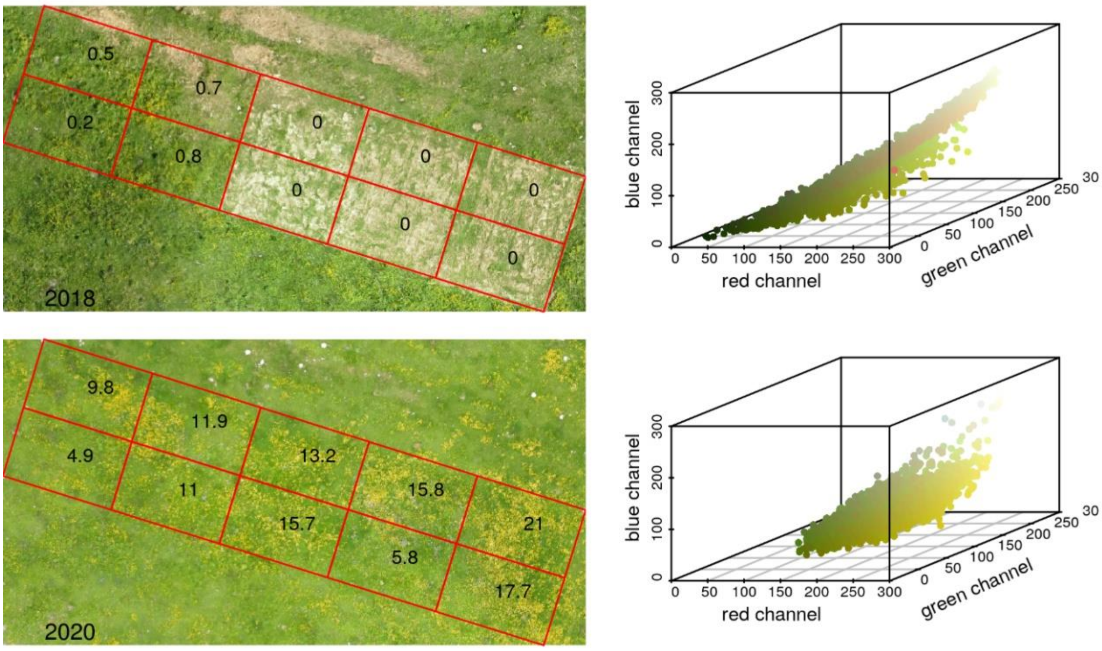

Figure 1. Aerial image of one block composed of ten subplots (left) and scatterplot of the colour values (right) in 2018 and 2020. Numbers in the left panel show yellowness.

The yellowness of the images generally showed good agreement with the share of buttercup as estimated by an independent observer (Figure 2). Correlation coefficients ranged from 0.25 to 0.93. The low correlations in 2017 and 2018 were mainly due to many zero values due to inappropriate timing of the image capture. In 2019 and 2020, when the S.O.D.A. camera was used and the timing was optimal, the correlation coefficients were above 0.85.

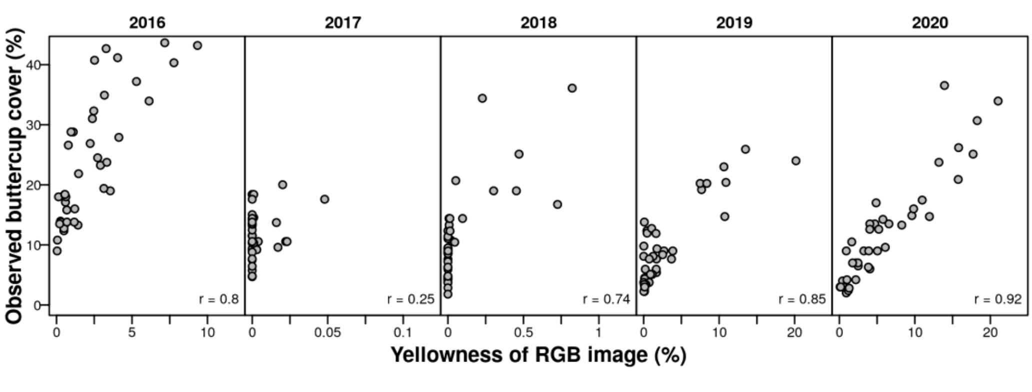

Figure 2. Correlation between the percentage yellowness in RGB images and the observed percentage cover of buttercup on the ground for the years 2016 to 2020. For each year, the coefficient of the correlation is given.

While the correlation between yellowness and observed buttercup cover was high, the absolute relationship varied between years. This can be seen in the different ranges of the x-axis in Figure 2. For example, an observed cover of 40% in 2016 corresponded to a yellowness of the image of 10%. In 2020, an observed cover of 35% corresponded to a yellowness of 20%. Although buttercup cover was observed by the same person every year, some fluctuation cannot be ruled out. The data of 2019 and 2020, nevertheless, suggest that yellowness can be used as an indicator of buttercup cover across years, if the camera and flight setup remain stable. The fact that none of the relationships followed the 1:1 curve demonstrates the importance of quantitative ground measurements.

Conclusions

Yellowness in RGB images is a valid indicator for yellow plant species such as buttercup. If a single species should be detected, it is important that it is the dominant flowering species. The accuracy of the indicator depends, importantly, on the quality of the images, namely the resolution, contrast and blurring. The data show that a unique relationship between yellowness of the image and observed buttercup cover can only be established across multiple years if a similar flight setup has been used. Nevertheless, the study demonstrates the potential of drone-based images in assessing the cover of dominant weed species.

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