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Digital Vegetation Charting: a robust and cost-effective technique for estimating plant cover, leaf litter, and bare ground in grassland areas

Enabling standardization of ground cover estimates across different sites

BACKGROUND

Grasslands cover vast areas and play an important role in supporting the livelihoods of rural communities living in arid and semi-arid ecosystems. Grassland productivity is highly correlated with rainfall and provides many ecosystem services. However, this productivity is curtailed by climate variability and anthropogenic pressures such as overgrazing and encroaching of cultivation.

The ability to obtain a good estimate of grassland productivity and change through time is therefore crucial, not only to local communities, but also to decision makers and society in general. Traditional methods of estimating ground cover are labor intensive and time consuming but the digital vegetation charting technique (DVCT) enables users to estimate the parameters of grassland vegetation and to monitor changes in grassland at a minimum cost and in a non-destructive manner.

Equipment set up in the field for DVCT

Measuring plant cover

Plant cover is one of the fundamental parameters measured by botanists. Cover is ecologically important because plant leaves and branches protect the soil from the damaging effects of heavy rainfall and reduce soil erosion (Royan et al. 2016). Furthermore, the greater the vegetation cover, the more vegetation is available for livestock and wildlife.

Agronomists, ecologists, and range scientists usually express plant cover as the percentage of the ground surface that is occupied by plant crown or shoot areas when the plant is projected vertically downward. Plant cover is easier to measure than biomass and provides a useful measurement of plant height and stratification within the vertical profile. Furthermore, there is a strong positive correlation between vegetation cover and biomass meaning that the former can be used as a surrogate for estimating the latter without destroying plant material (Louhaichi et al. 2018).

Traditional techniques for measuring plant cover

Traditionally, ecologists have used quadrats to monitor and assess the parameters of vegetation cover.

The benefits of DVCT are:

- It is a reliable, objective, and non-destructive method for estimating vegetation cover and assessing grassland health
- It can speed up data collection over time, reducing monitoring costs
- Images can be easily taken using a digital camera with a stand and processed rapidly in batches
- Unlike most commercial image-processing software, VegMeasure® is easy to acquire and use
- Monitored areas can be revisited each season or year to assess the spatial and temporal effect of natural and human-induced factors.

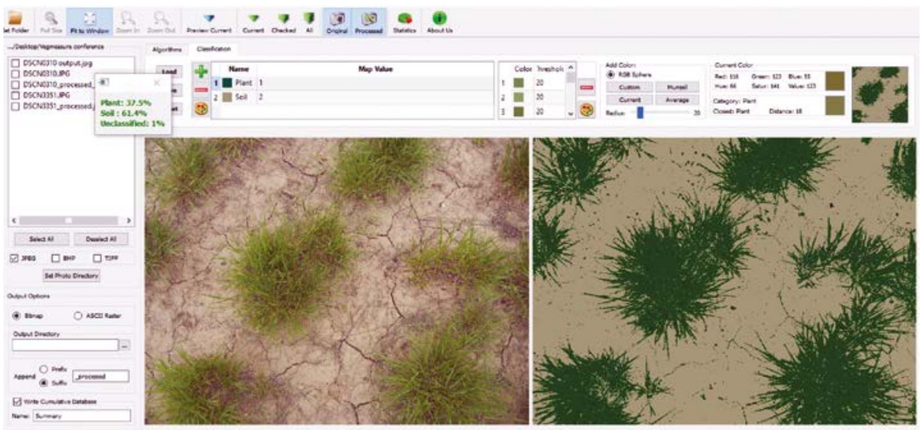
Of importance are plant cover, leaf litter, and the percentage of bare ground exposed to the erosive impact of rain. Parameters relating to these features are typically recorded by field personnel using field sampling techniques based on visual estimates. Unfortunately, these traditional techniques are subjective, time consuming, costly, and, at times, destructive (Serrano et al. 2018). Therefore, it is important to adopt new technologies which are easy to use, are cost and time efficient, and do not destroy vegetation (Louhaichi et al. 2010).

Using digital photographs and image processing to estimate plant cover

Advances in electronic technology have created new opportunities for vegetation and ecosystem monitoring. This has led to VegMeasure® – a software program developed by the VegMeasure® Project. The program aims to assess and monitor rangeland vegetation in a non-destructive manner. In particular, it allows grassland ecologists to create meaningful classes in order to measure the percentage cover of foliage, leaf litter, and bare ground, as well as other categories of interest.

The software program enables users to classify optical data by using hue extraction, calibrating a threshold, and establishing K-means classification, brightness algorithms, and green leaf algorithms. In this way, it provides natural resource managers with an objective means of rapidly collecting and displaying data on grassland plant cover to promote management decisions based on adequate and valid evidence. Furthermore, by repeating data collection over time, users can capture the impact of disturbances such as drought, as well as herbivory and other major environmental events.

The software program operates by using a mathematical formula (a ratio of the red, green, and blue colors in the visible spectrum). Pixel values indicate where green light (reflected) is most intense and where red and blue light (used by leaves in photosynthesis) are low.



Classification screen from the VegMeasure® program

Operating the DVCT equipment

Camera set up

Most surveys require a GPS-enabled digital camera with a 16 mega-pixel resolution or higher, mounted on a staff or pole that holds the camera at a height of 1.2–1.5 meters above ground (Booth et al., 2004). During photographic sampling, the camera should be always maintained in an upright position, so the GPS fixes are of the highest quality possible.

To set up the camera, the following steps should be followed:

- **Synchronize time.** The first step is to ensure that the time, date, time zone, image resolution, and GPS data recording are set correctly.
- **Select a high resolution.** It is important to detect the greatest amount of change, so make sure the camera is set to the highest resolution and lowest compression possible.
- **Enable GPS recording.** Make sure the camera can receive signals from the GPS satellites. If this function is not enabled, the camera cannot receive data and synchronize signals from GPS satellites with the data and time of the camera's internal clock.

When the camera is in use, the following should be considered:

- **Check camera position.** The camera must be in a vertical position, pointing towards the ground – a bubble level will indicate whether the camera is at the right angle or not.
- **Eliminate shadows.** It is important to eliminate shadows so that images can be processed and identified correctly. The camera needs to be oriented in a direction that will minimize shadow effects.

Image processing

Users should load images by clicking the "Set Folder" button to specify the directory which contains the photos they would like to process. For each site and date, it is recommended that users create a separate folder. It is usually sufficient to manually classify a few images (three to five) which are representative of the whole site. The more homogenous the site, the fewer images are needed.

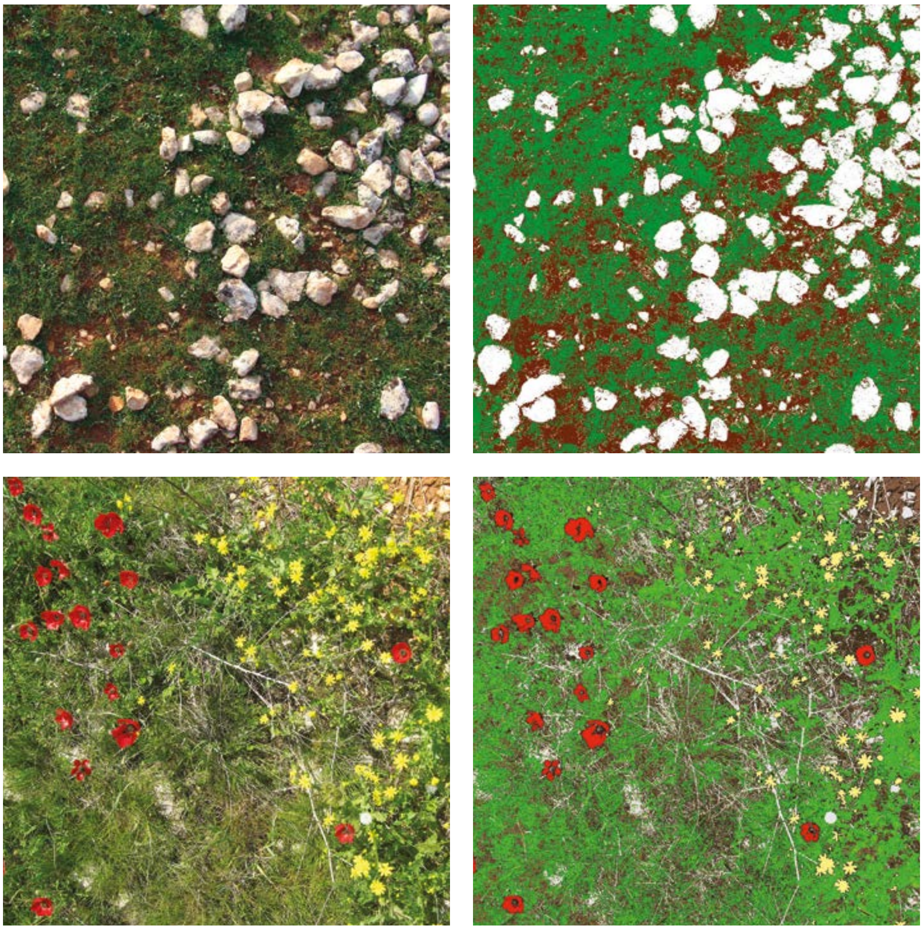
Image classification is an important process to help identify trends that inform monitoring and the effect of climate and management techniques. There are different types of classification: each has its advantages and disadvantages, and the best option will depend on what the data will be used for or what trend is being observed. Thus, it is important to understand the different classification techniques so that the most appropriate method is selected.

Supervised classification is the most commonly used option as it allows for more customizing of images. This technique is helpful when the user is looking to observe a specific value or trend. Once a user is satisfied with the output of selected images, the setting can be used to classify all images saved in the folder. Output from the program consists of a classified digital image (the output image km file, image info. file, and digital image bmp) with colors assigned to each class by the analyst. At the end of processing, a new summary file (.csv) will also be created in the output folder.

Classification accuracy is assessed using the accuracy assessment tool in VegMeasure® through computing the error matrix and the Kappa Index of Agreement. The error matrix permits the measurement of overall accuracy, category accuracy, producer's accuracy, and user's accuracy (Congalton, 1991).

Key points of the digital vegetation charting technique:

- Camera time should be synchronized with the GPS unit
- Camera should be fixed to the platform, e.g. monopod, blimp, drone
- Images should always be a landscape view of the site being monitored
- Camera should be pointing straight down
- Systematic sampling with straight parallel transects in a grid is usually the best option
- The more homogenous the site in terms of plant communities, the more distant the sampling points and images required and vice versa
- All images should be downloaded and saved into a folder for each site and sampling date
- The original images and classified images become a valuable data set that records and characterizes the condition of grassland at a specified location and time
- The data sets are extremely valuable in documenting grassland changes and trends.



Two original images (left) next to their processed images (right)

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SUMMARY

Developing protocols for vegetation sampling requires careful assessment of management goals in relation to the information gained. Overall, methods that are cost effective and objective are needed to detect important changes in vegetation within acceptable margins of error.

Compelling arguments for new vegetation sampling methods include a reduction in cost per sample, an increased speed of sampling, and the acquisition of permanent digital imagery. In particular, the DVCT provides quantitative information to aid understanding of grassland and shrubland ecosystem dynamics, monitor changes in the shrub carbon pool, and identify opportunities for climate change mitigation. The method also allows for the standardization of ground cover estimates between sites – something that cannot be accomplished when making visual estimates.

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