International Grassland Congress Proceedings
21st International Grassland Congress / 8th International Rangeland Congress

Estimating the Dry Matter of Grasses and Shrubs in Semi-Arid Zones Using Visible and Near-Infrared Wavelengths Recorded by High Resolution Aerial Photographs

Andreas Buerkert
University of Kassel, Germany

Stefan Siebert
University of Frankfurt, Germany

Bruno Gérard
ICRISAT, Germany

Wolfgang Schaeper
ICRISAT, Germany

Marco Buschmann
Technical University of Braunschweig, Germany

The 21st International Grassland Congress / 8th International Rangeland Congress took place in Hohhot, China from June 29 through July 5, 2008.

Proceedings edited by Organizing Committee of 2008 IGC/IRC Conference

Published by Guangdong People's Publishing House

Estimating the dry matter of grasses and shrubs in semi-arid zones using visible and near-infrared wavelengths recorded by high resolution aerial photographs

Andreas Buerkert[1], *Stefan Siebert*[2], *Bruno Gérard*[3], *Wolfgang Schaeper*[4] *and Marco Buschmann*[5]
[1] *Organic Plant Production and Agroecosystems Research in the Tropics and Subtropics, University of Kassel, Steinstrasse 19, D-37213 Witzenhausen, Germany, E-mail: tropcrops@uni-kassel.de*; [2] *Institute of Physical Geography, University of Frankfurt, P.O. Box 111932, D-60054 Frankfurt (Main), Germany*; [3] *ICRISAT Sahelian Centre, BP 12404, Niamey, Niger*; [4] *Kapellenweg 39, D-88090 Immenstaad, Germany*; [5] *Institute of Aerospace Systems, Technical University of Braunschweig, Hermann-Blenk-Str. 23, D-38108 Braunschweig, Germany*

Key words: drone, GIS-GPS, kite photography, NDVI, radiation analysis, remote control, shape recognition

Introduction Non-destructive estimates of plant biomass in semi-arid grasslands were for long hampered by the availability of high resolution radiation data. Recently IKONOS and QUICKBIRD satellite images have become available for all areas worldwide but their costs are in contrast to LANDSAT and SPOT datasets often prohibitive. Aerial photographs with a resolution of 5-10cm taken from kites or small remotely controlled drones are a low-cost alternative for areas where images from airplanes are hard to obtain and the size of study sites ranges from 1-2500ha.

Materials and methods At a weight of about 3kg each, the self-made, 1.8×2.5m kite and the drone of wing span 2.2m is able to carry a digital camera (Fuji F30) to altitudes of 100-1500m above ground (Figure 1). Exposure of pictures (kite and drone) and positioning of the drone (propelled by a battery-powered Hacker 50 geared brushless motor with 350W power) was performed with a standard remote control (Robbe/Futaba FC-28) with 100mW RF output in the 35MHz band. The equipment was used to take aerial images from 250m for dry matter (DM) determination of pearl millet (*Pennisetum glaucum* L.), grass mixtures and the shrub *Guiera senegalensis* in the African Sahel and of *Alhagi sparsifolia* in the Chinese Taklamakan desert. Ground measurements allowed to calibrate and validate the remote data.

Results and discussion For the studies in the African Sahel the GIS based analysis of true-colour and infrared aerial photographs permitted the quantitative monitoring of millet DM development throughout the growing season. Infrared images were most efficient in the detection of vegetation followed by the normalized green band of true-colour images. The red band of true colour images was the least effective because of soil albedo and image vignetting.

Analysis of true-colour images of the grass mixtures and the bare soil revealed that the number of normalised green band pixels averaged per plot was highly correlated with the DM of grass mixtures ($r = 0.86$) and that red band pixels were related to differences in soil surface crusting. The observed 2-yr residual effects of straw application and phosphorus fertilization on grass growth showed DM increases >100% and 14%, respectively.

Figure 1 *Kite (a) and remotely controlled drone (b and c) taking true colour and near-infrared aerial images of grass and bush vegetation.*

Regressions between the DM of *Guiera* coppices and their canopy area were satisfactory ($r = 0.76$ to 0.93) and permitted the calculation of the individual coppice dry matter for the entire field with fewer than 40 destructive measurements.

For the studies in China first and second order polynomial regressions between DM data of 50 ground-truthed *A. sparsifolia* shrubs and their respective canopy area allowed to automatically calculate the DM of all remaining shrubs covered by the photo-graph ($r^2 = 0.92$ to 0.96). The use of non-linear DM regression equations required an automatised separation of shrubs growing solitary or in clumps. Separation criteria were the size and shape of shrub canopies. The results showed that the GIS-based approach led to an overestimation of *A. sparsifoilia* DM in densely vegetated areas, a systematic error which decreased with increasing size of the surveyed area. The application of the described techniques for vegetation monitoring in the Chinese-Mongolian Altay is discussed.

Conclusions Today's image processing techniques true-colour and infrared images taken from self-made high resolution images of desert vegetation allow to quantify their above ground biomass and measure treatment effects. For successful application strong contrasts between vegetated areas and bare ground, simple plant stands of few species, enough geo-referenced points to correct for distortions of the images and destructive DM data for calibration are needed.