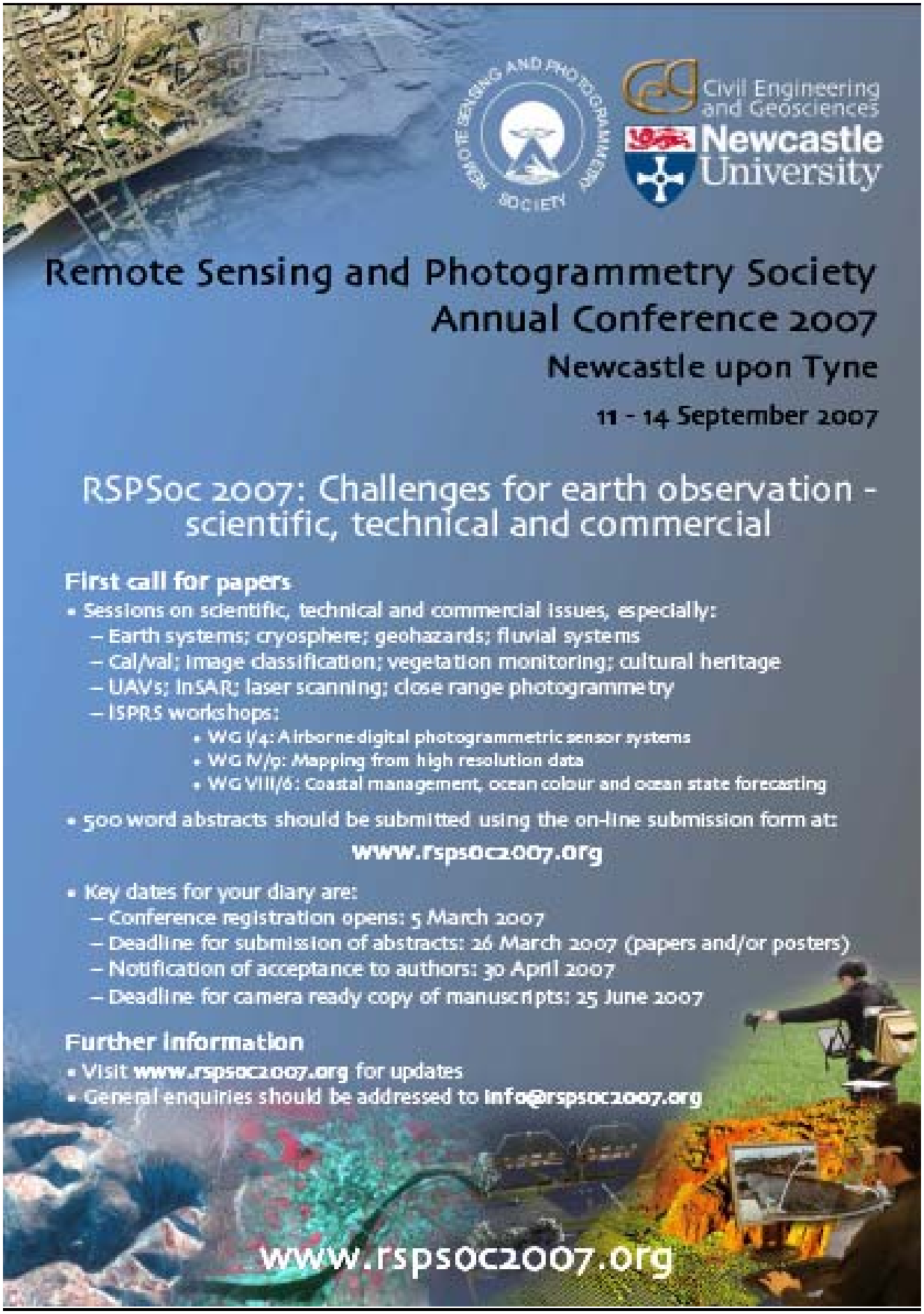
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Biomass estimates of semi-arid vegetation from airborne remote sensing in Sorbas, South-east Spain

Gary Parker, Paul Zukowskyj, Adriano Sofo

This study utilises CASI and ATM airborne data from three time periods; 1996, 2001 and 2006, to assess the changes in semi-arid vegetation in the area immediately south of Sorbas, South East Spain. The data was orthocorrected using a combined LiDAR/Photogrammetric DEM within NERC's AZGCORR software, producing a closely co-registered data series. The image mosaics produced were then manipulated to produce a variety of Vegetation Indices (VI).. Using Pearson's correlation, each VI has been correlated with ground truth data to evaluate the relationship between the VI and the Above Ground Biomass (AGB) of the area. The ground truth data comprises AGB estimates from three meter square clear-cut quadrats adjusted for moisture content to provide dry-weight biomass estimates. Quadrats were selected from areas that covered the range of expected biomass values, from <8 tonnes/Ha (wet weight) to >80 tonnes/Ha (wet weight) and were reasonably representative of the surrounding contiguous area to reduce pixel mis-location errors. Initial correlations from the 2006 ATM data for NDVI, OSAVI and SAVI are all around 0.94. It is expected that the CASI data will also have very high correlations as band midpoints are more suited to a number of the VI used. An assessment of the VI and how they correlate with AGB will provide information on which VI is most appropriate for the semi-arid vegetation types seen in this area. Validation ground data have also been collected, effectively providing an independent dataset for confirmation of the VI predicted biomass values throughout the image. Initial validation quadrat results have been correlated using Pearson's Correlation with the 2006 ATM data. Correlations for NDVI are around 0.85, demonstrating the ability of the NDVI to predict AGB accurately enough for a regional assessment of biomass values with this VI. Total biomass in the imaged area will be estimated using a sub-pixel classification technique to determine vegetation type and, in combination with the AGB estimates, ratios for Below Ground Biomass from the research literature. Carbon per Biomass measures undertaken on samples collected from the field can then be applied to the total biomass and a carbon value can be estimated for the area for each year data was collected. This will allow a temporal comparison to be carried out, providing information on the total carbon budget for the natural vegetation, whether increasing or decreasing. The study will enhance the body of scientific knowledge of Carbon sequestration in semi-arid Europe, and may have implications for the European Union Common Agricultural Policy, which currently provides subsidies for extensive agriculture in the region, resulting in the destruction of the natural vegetation in the area.

BIOMASS ESTIMATES OF SEMI-ARID VEGETATION FROM AIRBORNE REMOTE SENSING IN SORBAS, SOUTH-EAST SPAIN

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KEY WORDS: Ecosystem, Hyper spectral, Vegetation, Change Detection, Temporal

EXTENDED ABSTRACT:

This study utilises CASI and ATM airborne data from three time periods; 1996, 2001 and 2006, to assess the changes in semi-arid vegetation in the area immediately south of Sorbas, South East Spain (figure 1).

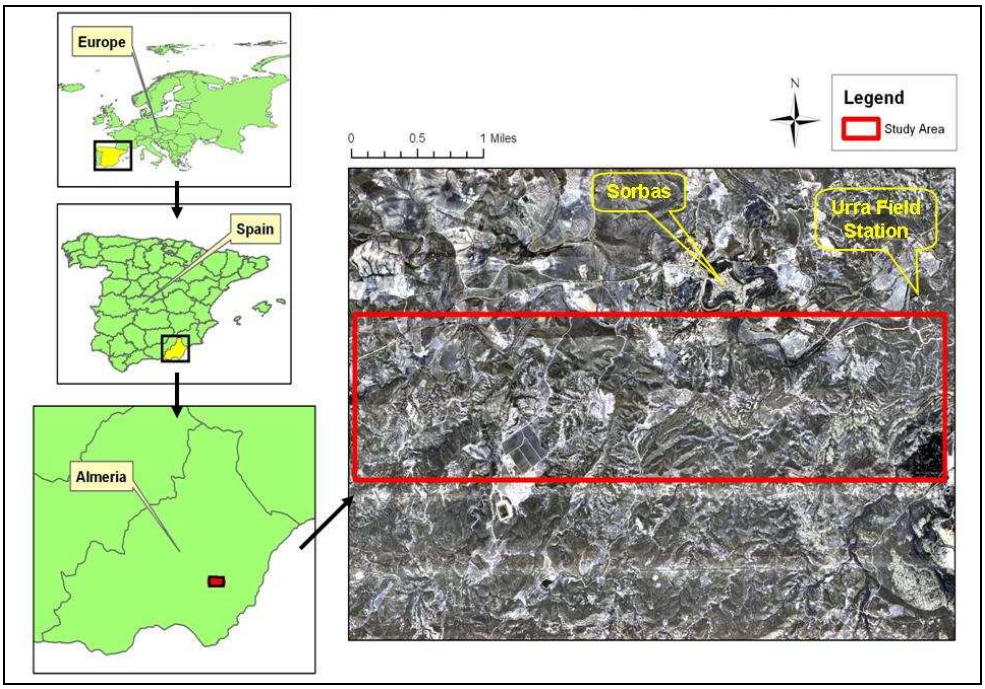

Figure 1. Location of the study area in relation to the rest of Europe and Spain. Red box denotes overlap of time series data and therefore area for analysis

The three chronological datasets were orthocorrected using a combined LiDAR/Photogrammetric DEM within NERC's AZGCORR software, producing a closely co-registered data series. The image mosaics produced were then manipulated to produce a variety of Vegetation Indices (VI).. Using Pearson's correlation, each VI was correlated with ground truth data to evaluate the relationship between the VI and the Above Ground Biomass (AGB) of the area. The ground truth data comprises AGB estimates from $9m^2$ clear-cut quadrats adjusted for moisture content to provide dry-weight biomass estimates. Quadrats were selected from areas that covered the range of expected biomass values, from <8 tonnes/Ha (dry weight) to >80 tonnes/Ha (dry weight) and were reasonably representative of the surrounding contiguous area to reduce pixel mis-location errors. VI to AGB correlations from the image datasets are encouragingly high (table 2), despite the need to reduce the number of ground points used for correlation with the older datasets.

	NDVI	TVI	GNDVI	DVI	Savi	Osavi	Savi2	RDVI	MSR	MCARI1	MCARI2	MTVI1	MTVI2
ATM2006	0.94	0.90	0.89	0.90	0.94	0.94	0.94	0.95	0.93	0.90	0.90	0.90	0.91
ATM2001	0.94	0.82	0.80	0.81	0.94	0.94	0.94	0.93	0.90	0.80	0.90	0.80	0.84
ATM1996	0.85	0.93	0.79	0.91	0.85	0.85	0.85	0.95	0.89	0.93	0.81	0.93	0.82
CASI2006	0.93	0.86	0.85	0.84	0.88	0.93	-0.93	0.93	0.91	0.85	0.89	0.85	0.84
CASI2001	0.96	0.74	0.62	0.55	0.97	0.96	0.90	0.81	0.84	0.80	0.93	0.80	0.87

Table 2. Pearson's correlation values between measured ground biomass and a range of vegetation indices for five of the six available datasets.

Perhaps surprisingly for a fragmented community in a semi-arid region, NDVI performed as well as the alternative and more complex modified vegetation indices, designed to adjust for soil brightness and shadowing effects, at predicting AGB.

The correlation between NDVI and AGB has therefore been utilised to estimate total AGB in the study area, through non-linear regression of the observed relationship. Use of plant biomass ratios for AGB to below ground biomass from previous research have then been utilised through image classification to provide a general estimate of total biomass and consequently biomass change over the decade of observations.

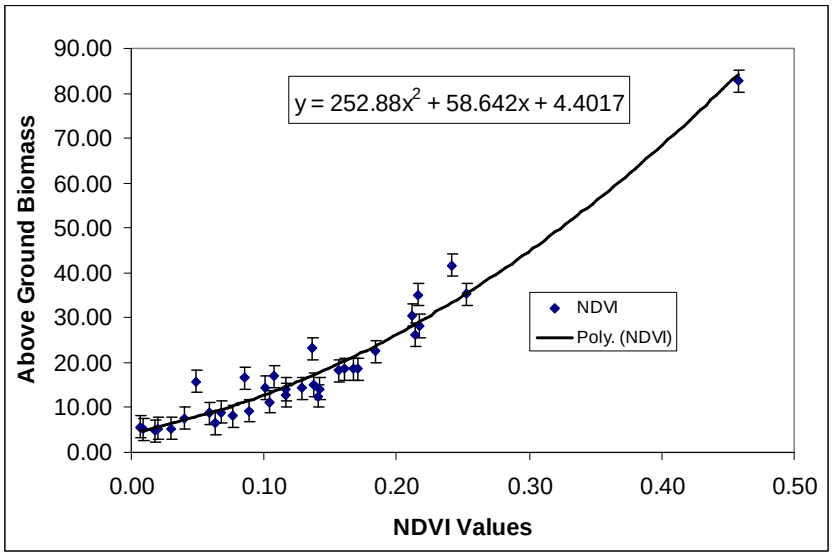

Figure 3. Polynomial regression between NDVI image values for the 2006 ATM and ~35 ground truth quadrats measured AGB.

Validation ground data have also been collected, effectively providing an independent dataset for confirmation of the VI predicted biomass values throughout the image. Initial validation AGB quadrat results have been correlated using Pearson's Correlation with the 2006 ATM data. Correlations for NDVI are around 0.85, demonstrating the ability of NDVI to predict AGB accurately enough for a regional assessment of biomass values with this VI.

Total biomass in the imaged area has been initially estimated using a maximum-likelihood classification technique to determine vegetation type and, in combination with the AGB estimates, ratios for Below Ground Biomass from the research literature. Carbon per Biomass measures undertaken on samples collected from the field have then been applied to the total biomass and a carbon value estimated for the area for each year data was collected (table 4).

Sensor/Year	Total Area Carbon	Total Area (Ha)	Kg C / Ha	tC/Ha
ATM 1996	45984898	1335	34446	34.45
ATM 2001	36702104	1335	27492	27.49
ATM 2006	49391272	1335	36997	37.00
CASI 2001	57994496	1335	43441	43.44
CASI 2006	65669801	1335	49190	49.19

Table 4. Initial carbon per hectare estimates.

This should have allowed a temporal comparison to be carried out, providing information on the total carbon budget for the natural vegetation, whether increasing or decreasing. The initial data indicates an overall upward trend over the decadal climatic cycle of the region, however the disparity between the CASI and ATM results is of some concern. Clearly the classification process may be a source of significant error in this and further work is needed to clarify the source of the discrepancy between the two sensors results. The final study will enhance the body of scientific knowledge of Carbon sequestration in semi-arid Europe, and may have implications for the European Union Common Agricultural Policy, which currently provides subsidies for extensive agriculture in the region, resulting in the destruction of the natural vegetation in the area.