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WHAT'S IN A PHOTOGRAPH? A COMPARISON OF PHOTOGRAPHIC AND FIELD MEASUREMENT TECHNIQUES FOR MONITORING SITES IN THE SOUTHERN RANGELANDS OF WESTERN AUSTRALIA

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ABSTRACT

This ongoing study is examining the efficacy of using photographic interpretation to derive selected landscape function indices, as part of a larger study of rangeland ecological health. The internal representativeness of 12 Western Australian Rangeland Monitoring System (WARMS) monitoring sites, located on a variety of land systems, was examined by comparing the same indices acquired by three different, quadrat-based, methods: (1) routine transect field measurement, (2) photosite field measurement, and (3) photosite photo-interpretation. Correlation and regression analyses reveal that Soil Surface Condition (SSC) indices (soil stability, water infiltration, nutrient cycling) have very strong associations between the three methods. Based on this study, photo-interpretation can effectively derive robust and consistent SSC indices, and although not yet able to infer results of a physical soil test such as slake, have wide application in landscape and catchment function mapping and monitoring, in conjunction with field programmes.

INTRODUCTION

This study is examining the efficacy of using photographic interpretation techniques to derive selected landscape function indices. It is part of a larger project concerned with producing regional scale interpretations of changes in the ecological health of the southern rangelands of Western Australia over the last three decades or so. These changes, to be mapped in space and time, are being derived from an analysis of historical and contemporary data held by the Western Australian Department of Agriculture in its WARMS (Western Australian Rangeland Monitoring System) database. WARMS is designed to provide data on rangeland condition by monitoring the long-term status of perennial plants and soil surfaces. For the southern rangelands, each monitoring site (Fig. 1) consists of a trapezoid-shaped photosite (121 sq m), and three contiguous, parallel belt transects (each 60 to 400 sq m). There are 996 current, permanently marked, shrubland sites, and many more old WARMS and Pastoralist Monitoring Sites (PMS). All data, apart from NDVI (Normalised Difference Vegetation Index), are acquired by field measurement in a five-year reassessment cycle. Transect data collected include plant species and metrics (height, maximum width, location), and a suite of attributes for Landscape Function Analysis (LFA) and Soil Surface Condition (SSC) assessment. On the adjoining photosite, a plant count by species is done, and a single low-angle oblique photograph is taken from a set position.

To date, photographs have been used by pastoralists and Department of Agriculture staff, only as a visual record of local range condition. Showing changes through time at approximately five-year intervals, these photographs are a very valuable but presently under-utilised resource. It is an aim of this study to develop techniques to extract three-dimensional (3-D) plant metrics and soil surface condition (SSC) attributes from repeat 2-D photographs so as to be able to calculate certain indices of ecological health. For a recent review of the use of repeat photography in landscape studies, see Pickard (2002). Work on the SSC aspects is essentially complete and is outlined here but work on the 3-D aspects is still in progress (companion study for doctoral thesis).

METHODS

Given that the overarching ecological health project relies, in part, on the interpretation of historical monitoring site photographs, a critical aspect is to establish that data collected from a photosite, whether through field measurement or photo-interpretation, are a good analogue of the transect data. In other words, do the photosite and associated transects tell the same story? This concern applies equally to the SSC data (discussed here) and the plant data (companion study).

The internal consistency of the 12 WARMS sites selected for this orientation study (Table 1), is examined by comparing the same SSC indices acquired by three different, quadrat-based, methods: (1) routine transect field measurement, (2) photosite field measurement, and (3) photosite 2-D photo-interpretation. The SSC indices are soil stability, water infiltration and nutrient cycling (Tongway, 1994), calculated from the following suite of soil surface attributes: soil cover (rain interception), soil cover (surface flow interception), crust broken-ness, cryptogam cover, erosion type and severity, extent of deposited material, litter cover, surface microtopography, surface nature, texture and slake. These attributes are fully described by Tongway (1994).

Table 1. WARMS orientation study sites and land systems – Southern Rangelands.

SITE NO	*REGION*	*LAND SYSTEM* *
WIL_009	Carnarvon	**Phillips:** stony rounded hills, uplands, lower interfluves & gently sloping drainage flats over granite/gneiss/dolerite: acacia & chenopod shrubland.
WIL_017	Carnarvon	**Jimba:** gently sloping alluvial plains on Permian sedimentary rocks, occas. stony plains & low rises, chenopod & patchy acacia shrubland.
WIL_028	Carnarvon	**Durlacher:** stony flat plains, low rounded hills & upper interfluves over granite/gneiss; acacia & chenopod shrubland & low woodland.
NAM_018	Meekatharra	**Carnegie:** saltlakes, saline flats, sandy banks, halophytic shrubland.
NAM_030	Meekatharra	**Gransal:** stony plains & low rises on granite, halophytic shrubland.
YAN_082	Meekatharra	**Darlot:** saltlakes, saline alluvial plains, sandy banks, claypans, halophytic shrubs, spinifex & wanderrie grassland.
GUN_002	Nullarbor	**Gunnadorah:** flat, smooth clay & kankar plains, some 'dongas' (drainage foci) & claypans, over Nullarbor Limestone; sparsely wooded bluebush shrubland.
KIN_002	Nullarbor	*Not yet mapped*
NTS_133	Nullarbor	*Not yet mapped*
PON_162	Nullarbor	*Not yet mapped*
RAW_109	Nullarbor	*Not yet mapped*
VIG_004	Nullarbor	*Not yet mapped*

* Land system descriptions summarised from inventory and condition survey reports by Pringle *et al.* (1994), Curry *et al.* (1994), Payne *et al.* (1980), and Mitchell *et al.* (1988).

The orientation study sites represent a wide variety of land systems and soil conditions.

Routine transect field measurement

Landscape function analysis (LFA), including SSC field assessment techniques, are comprehensively described in Tongway (1994) (the "brown manual") and the latest revision (Tongway, in press). On WARMS transects, the 11 SSC attributes are assessed for each of 20 x 1 sq m quadrats, and the patch type (shrub or inter-shrub) within which each quadrat occurs, is also noted. The quadrats are not photographed. The SSC analysis spreadsheet (to calculate the SSC indices) allows input of up to six quadrats for each patch type. In practice, this study found that the total number of quadrats used in analysis ranged from six to ten for each monitoring site transect. For those patch types with more than six quadrats, six quadrats are randomly selected.

Photosite field measurement

Within the photosites, 5 x 1 sq m quadrats were utilised. For all 12 sites, the set of quadrats was positioned so as to 'capture' the complete range of soil conditions based on a brief inspection of the site. This layout format is termed 'selected-position' and, obviously, the layout was different for each site. For the six Nullarbor sites only, a second format was incorporated into the study. This additional format, termed 'fixed-pattern', was designed to preclude potential operator bias in the SSC data collection, by sampling the site according to a fixed quadrat pattern (Fig. 1), irrespective of the distribution of soil condition classes.

All quadrats were digitally photographed prior to field assessment, so as to record minimally disturbed soil surfaces, with the camera (wide-angle setting) held by hand approximately 1.45 m above one edge of the quadrat. Infrequently, a bushy shrub partially obscured the soil surface, in which case, a second photograph was taken from a different position to supplement the first.

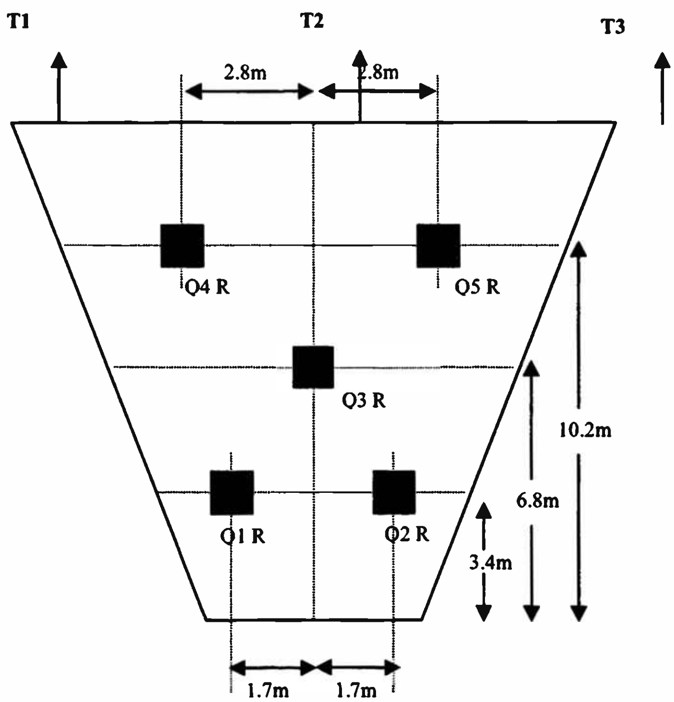

Figure 1. WARMS photosite 'fixed-pattern' layout of 5 x 1 sq m SSC quadrats.

Field assessment of the SSC attributes was undertaken on each of the quadrats (both formats for Nullarbor sites) using the standard transect procedure, and the data used to calculate the SSC indices, using the same spreadsheet analysis as used for the transect quadrats.

Photosite photo-interpretation

Quadrat photographs were downloaded as jpeg files to a laptop and displayed using MS Photo Editor. This software provides basic functions such as colour balance adjustment and zoom in/out. Photo-interpretation of quadrats was undertaken by the author many days or weeks after the field assessments, to minimise 'retained memory' effects, and in randomised order from the sites.

Interpretation consisted of making a judgement on the appropriate value or class for each of the SSC attributes except 'slake'. Slake is the only attribute which was not interpreted from the photographs; its value obtained from the WARMS database from previous field measurement. All photosite quadrats were photo-interpreted and used in the calculation of the SSC indices, using the same spreadsheet analysis as used for the field-assessed transect and photosite quadrats.

RESULTS

All photosite and transect SSC indices for the 12 orientation study sites are tabulated in the Appendix (Table 3). The transect data are considered to be the reference set (the 'independent variable') by which the photosite data ('dependent variables') are compared. Results of correlation and regression analysis of the indices are presented in Table 2 and Figure 2, respectively.

Table 2. Combined SSC Indices – Pearson rank correlation coefficients (r) matrix.

	Tr-FM	*Ph-SP-FM*	*Ph-SP-PI*	*Ph-FP-FM*
Ph-SP-FM	0.958			
Ph-SP-PI	0.952	0.987		
Ph-FP-FM	0.920	0.987	0.987	
Ph-FP-PI	0.943	0.985	0.993	0.990

Abbreviations: Tr transect, Ph photosite, FM field measured, PI photo-interpreted, SP selected-position (quadrat layout), F-P fixed-pattern (quadrat layout).

Analyses of the combined SSC indices show very strong correlation ($r > 0.920$) between photosite and associated transect indices, irrespective of assessment method (field or photo-interpretation) and quadrat layout format (selected-position or fixed-pattern). Within photosites, SSC correlations are similarly very strong ($r > 0.987$), exemplified by the selected-position and fixed-pattern formats, irrespective of assessment method (field or photo-interpretation).

The regression analysis (Fig. 2) supports the strong associations established by correlation analysis. For each of the four treatments (Fig. 2; (a) - (d)), the slope of the regression line is 1.00 ± 0.06, indicating a 1:1 direct relationship between transect and photosite measured SSC indices. Regression shows no significant difference in the photosite SSC values collected by field measurement or by photo-interpretation, using both quadrat layouts, compared with transect SSC values. The indices from all sites, except one (KIN_002, labelled on Fig. 2), fall within the 90% prediction envelope and most fall within the 90% confidence envelope.

DISCUSSION

This study has shown that SSC data collected from the photosite are directly comparable with data collected from their associated transect. With few exceptions, the photosite is representative of the monitoring site as a whole. Within the photosites, no sampling format (selected-position or fixed-pattern) or data acquisition method (field or photo-interpretation) is clearly superior or inferior with respect to data quality.

Contrary to expectations, given the different aggregate sample sizes, the range in values of the SSC indices captured within photosites is similar to the range captured by transects. From this, an initial conclusion is that the transects, in many cases, sample more than is necessary in order to derive representative SSC indices. However, an example that does not support this conclusion is site KIN_002, which plots well outside the 90% regression envelopes. It is an excellent example of the sensitivity of the SSC indices to detecting and quantifying landscape heterogeneities. Perusal of the SSC indices for this site (Table 3, particularly water infiltration) shows a large difference between the transect and photosite values. This is not an error in data collection; rather, the values reflect very marked heterogeneity across the monitoring site with the photosite occurring almost entirely beneath two large Western myall (*Acacia papryocarpa)* trees forming a patch zone with good litter cover whilst the transects run entirely across a wide interpatch zone with minimal litter cover. Other sites such as WIL_028 and NTS_133 (Table 3) also show some intra-site heterogeneity, but not as distinctly as KIN_002.

Overall however, the WARMS sites show a low amount of intra-site heterogeneity indicating that most are tightly located in relatively homogeneous portions or components within spatially organised landscapes. In conclusion, this study has shown that the interpretation of 2-D photographs of soil surfaces can produce reliable and consistent SSC indices, which may then be used as one measure of landscape health. The photo-interpreter does need to have field experience in assessing soil surfaces, and regardless of whether correct values for the slake test can be consistently inferred from photographs, there will always be a need for a field component to supplement and 'ground truth' any programme of photo-interpretation.

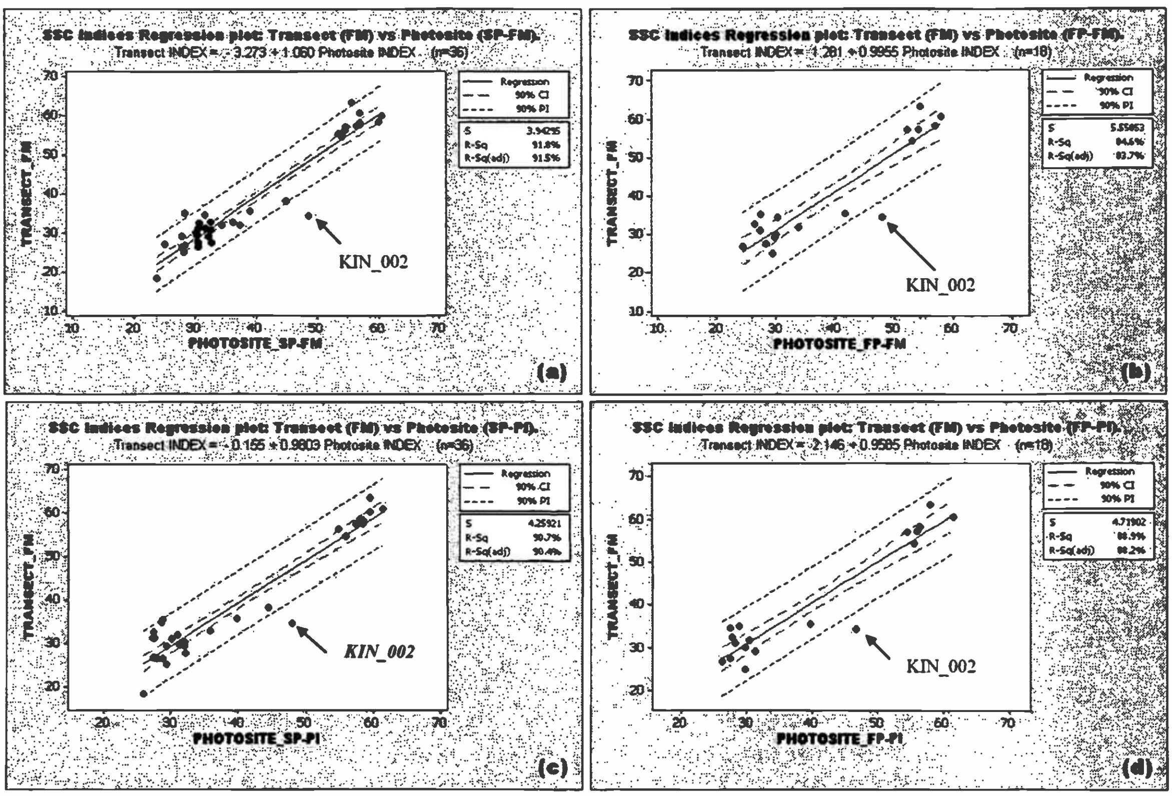

Figure 2. Linear regression plots of combined Soil Surface Condition (SSC) indices. Transect field measured (FM) indices are plotted against photosite indices derived from (a) selected-position (SP), field measured (FM) quadrats, (b) fixed-pattern (FP), field measured (FM) quadrats, (c) selected-position (SP), photo-interpreted (PI) quadrats, and (d) fixed-pattern (FP), photo-interpreted (PI) quadrats. 90% confidence and prediction intervals are shown.

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APPENDIX

Table 3. Abridged table of Soil Surface Condition (SSC) results.

WARMS SITE No	TRANSECT		PHOTOSITE (5 Quadrats per site)			
			SELECTED-POSITION QUADRATS		*FIXED-PATTERN QUADRATS*	
	FIELD		FIELD	PHOTO-INTERP	FIELD	PHOTO-INTERP
	INDEX (%)	*N° of QUADRATS*	*INDEX (%)*	*INDEX (%)*	*INDEX (%)*	*INDEX (%)*
			SOIL STABILITY INDEX			
GUN_002	57.4	7	56.5	57.5	54.0	56.0
KIN_002	58.3	9	57.0	58.5	57.0	56.5
NAM_018	58.4	8	60.0	58.0	no data	no data
NAM_030	57.6	10	57.0	no data	no data	no data
NTS_133	63.4	10	55.6*	59.5*	54.4	58.0
PON_162	54.5	8	54.0	56.0	53.0	55.5*
RAW_109	60.7	7	57.0	61.5	58.0	61.5
VIG_004	57.2	8	54.6	58.5	52.2	54.5
WIL_009	60.1	6	60.5	59.5	no data	no data
WIL_017	56.1	8	54.5	55.0	no data	no data
WIL_028	38.0*	9	45.0	44.5	no data	no data
YAN_082	55.3	8	53.5*	no data	no data	no data
			WATER INFILTRATION / RUNOFF INDEX			
GUN_002	31.8	7	34.4	30.9	33.7	30.4
KIN_002	34.3	9	48.5	48.1	47.9	46.7*
NAM_018	31.1	8	30.5	27.6	no data	no data
NAM_030	32.0	10	37.3*	no data	no data	no data
NTS_133	30.0	10	30.1	32.0*	29.8	29.7
PON_162	31.0	8	31.6*	27.2	27.2	28.3
RAW_109	24.9	7	28.2	29.3	29.3*	29.7
VIG_004	27.5	8	30.4	32.1	28.2	27.4
WIL_009	29.1	6	32.1	32.0	no data	no data
WIL_017	29.3	8	30.3	31.2	no data	no data
WIL_028	32.7	9	36.3	35.9	no data	no data
YAN_082	32.6	8	32.4	no data	no data	no data
			NUTRIENT CYCLING INDEX			
GUN_002	34.5*	7	31.6	28.6	30.2	27.4
KIN_002	35.4	9	39.0	39.9	41.8	39.7*
NAM_018	26.3	8	27.9	27.9	no data	no data
NAM_030	27.5	10	32.6*	no data	no data	no data
NTS_133	35.1*	10	28.4	28.8*	27.4	28.8
PON_162	32.5	8	30.7	27.4	26.3	27.7
RAW_109	29.1	7	27.9	29.3	29.7*	31.3
VIG_004	26.7	8	28.4	27.4	24.3	26.4
WIL_009	26.4	6	30.5	28.8	no data	no data
WIL_017	30.7*	8	32.5	30.1	no data	no data
WIL_028	18.3*	9	23.7	25.9	no data	no data
YAN_082	27.1	8	25.1	no data	no data	no data

* Result for which the standard error (SE) exceeds by more than 1 standard deviation (SD), the mean SE calculated for each column of indices.

All field measurements done according to procedures described in Tongway (1994). Indices calculated using MS Excel workbook (vers. 2.2, 10 July 2001) kindly supplied by David Tongway (CSIRO, Canberra).