NATURE: A COLOUR COMPARISON BETWEEN NORTHERN SOUTH AFRICA AND NORTHERN AUSTRALIA

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ABSTRACT
During 1983 DSTO in Australia measured the reflectances of grass, trees and soil in northern Australia, using a custom-build spectroradiometer. During 2002 CSIR in South Africa performed similar measurements in northern South Africa, using a commercial spectroradiometer. The measurement areas in South Africa and Australia have the same kind of topography and maximum average temperatures. The largest difference is rainfall, where northern Australia experiences more tropical weather systems, with up to six times more rain than northern South Africa. This has a significant influence on the vegetation. The vegetation of the Australian measurement sites is predominantly classified as Eucalyptus, while the South African sites are classified as Bushveld, with much more diverse plant growth. All spectral data was referenced to a calibrated white standard, and for comparison purposes been converted to CIELAB notation. In this document he L*a*b* components were plotted on two sub-plots, the first representing the L*-values, the second showing the a*b*-values. The colour of the grass (winter) for both countries is close to each other, but the South African grass is much lighter than the Australian grass. The colour difference is between 7 and 15 dE units (a colour difference of one dE unit is just noticeable with the human eye). The colour of the trees for both countries is also very close to each other, the Australian trees being greener than the South African trees. The colour difference is between 3 and 6 dE units. The colour differences of the grass and trees could be contributed to the higher rainfall in Australia. The soil colour for both countries is also close to each other. The South African soil is more yellow than the soil in Australia. The soil has a colour difference of between 4 and 7 dE units. In general, the data shows the colours of natural elements in South Africa are lighter than those in Australia. The data also shows that the South African colours are more chromatic than those measured in Australia. Over and above the military application, this might find application in the remote sensing industry as well as the fashion– and interior decorating industry.

Keywords: Colour, Nature, South Africa, Australia, CIELAB

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INTRODUCTION

During 1983 Russell J. Boyd measured the reflectances of grass, trees and soil in northern Australia [Boyd, 1995]. He measured the reflectances in the field, using a custom-built spectroradiometer. The purpose of his measurements was to compare nature's colours with the camouflage colours used on military vehicles. These measurements were done during both the low- as well as the high-rainfall season.

During the same time A. Boettcher performed similar measurements in South Africa, but due to the technology available to him he collected samples in the field, and then measured the reflectances in the laboratory using a spectrophotometer [Boettcher, 1982]. The purpose was to determine the optimal camouflage colours to be used on military vehicles. During 2002 CSIR purchased a Spectrascan PR 715 instrument (which is sensitive in the visible and near infrared wavelengths), which enabled us to measure the reflectances in the field. The purpose was to validate the camouflage colours selected 20 years earlier, which were still used on military vehicles. The majority of our measurements were taken during late winter and start of spring [Baumbach, 2004].

GEOGRAPHY

Boyd took measurements at the following sites, as shown on the vegetation map in Figure 1:

- Queensland: Townsville and Cairns, both coastal towns
- Northern Territory: Darwin (coastal town) and Katherine (approximately 250 km from the nearest coast)
- Western Australia: Derby (coastal town) and Tom Price (approximately 300 km from the nearest coast).

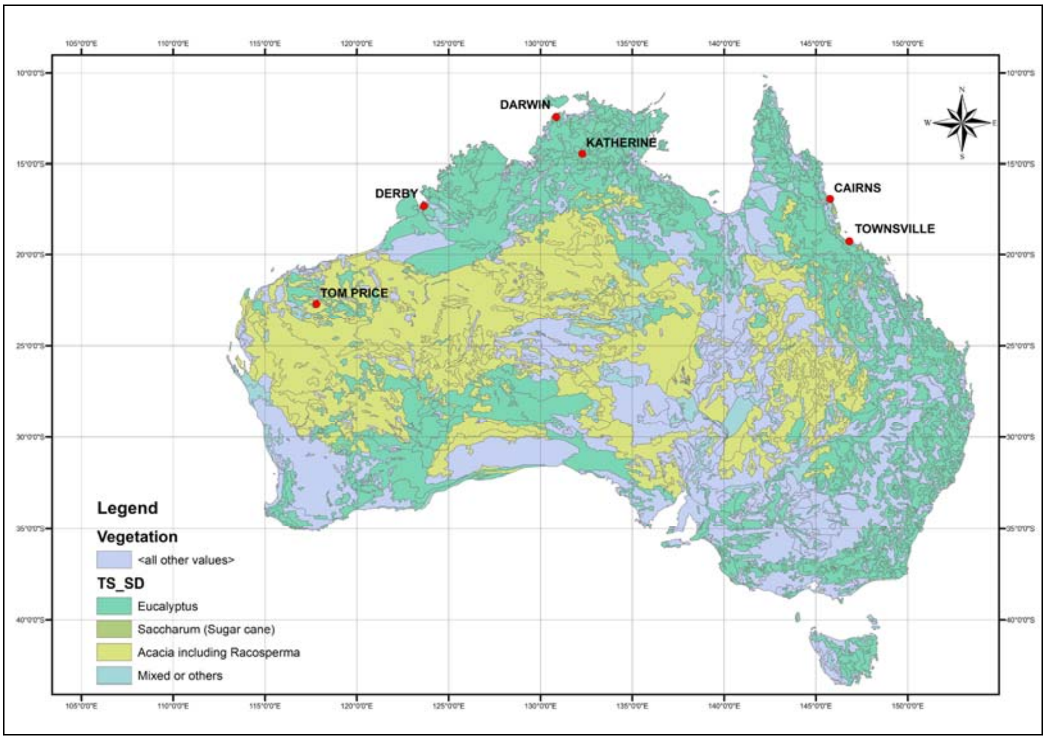

Figure 1: Vegetation Map of Australia, indicating Measurement Sites

In South Africa, Baumbach and Jones took measurements at the following sites, as shown on the vegetation map in Figure 2:

- Northern KwaZulu-Natal: Maputa (within 75km from the eastern coast)
- Southern part of the Kruger National Park: Skukuza, which is along the border with Mozambique, approximately 500km from the coast
- In the Limpopo Province, along the Limpopo river, which is the southern border of Zimbabwe (Messina), as well as along the border with Botswana (Ellisras), approximately 900km from the coast

Australia is by far larger than South Africa. If the areas of the countries [Readers Digest, 2004] are compared, Australia (7 682 399 km^2) is more than six times larger than South Africa (1 211 037 km^2). The Australian measurements were taken over a much larger area than the South African measurements.

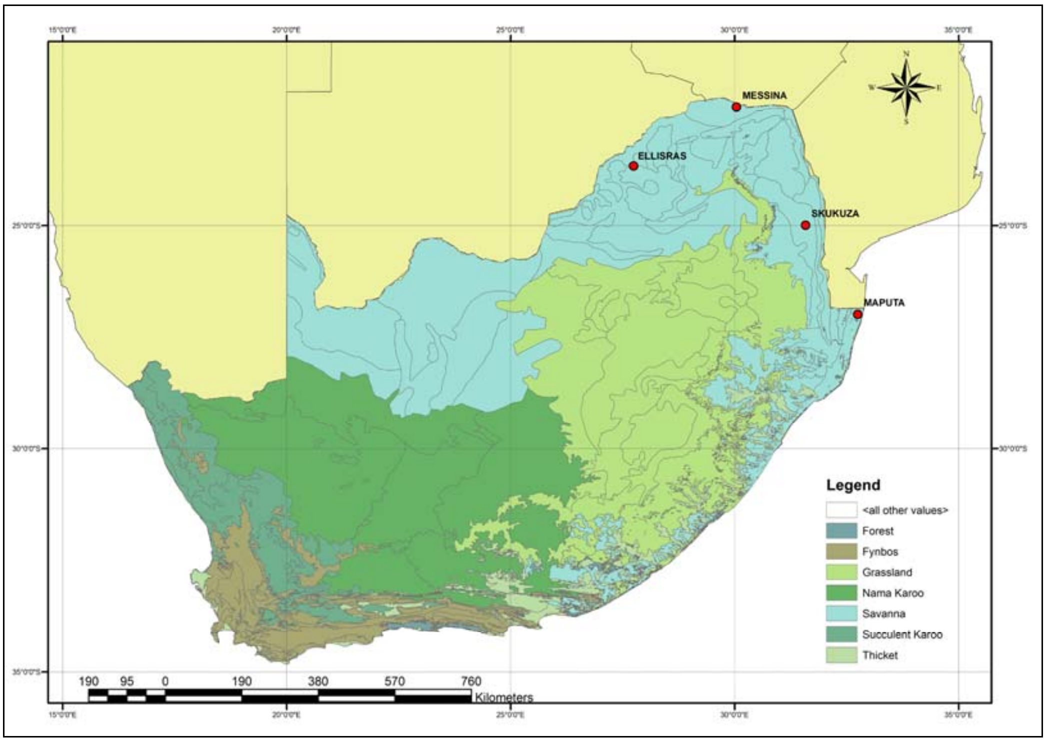

Figure 2: Vegetation Map (Biomes) of South Africa, indicating Measurement Sites

Table 1 shows the rainfall [Australian Bureau of Meteorology, Jan 2009], vegetation [Geoscience Australia, Jan 2009], topographic features [Geoscience Australia, Jan 2009] and average maximum temperature [Australian Bureau of Meteorology, Jan 2009] for the areas studied in Australia.

Table 2 shows the rainfall [South African Weather Service, Jan 2009], vegetation [National Botanical Institute, Jul 2001], topographic features [Geology Society of South Africa, 1985] and average maximum temperatures [South African Weather Service, Jan 2009] for the areas studied in South Africa.

Table 1: Rainfall, Vegetation, Geology and Average Maximum Temperature for Northern Australia

AUSTRALIA	**Avg. Rainfall (mm)**	**Vegetation**	**Topographic features**	**Avg. Max Temp (deg C)**
Townsville	1117	Eucalyptus	Hills and ridges	29
Cairns	1995	Mixed	Mountains & plateau	29
Darwin	1847	Eucalyptus	Plateau & planes	32
Katherine	984	Eucalyptus	Plateau & planes	34
Derby	673	Eucalyptus	Low plateau & planes	35
Tom Price	406	Acacia	Ridges & planes	31

Table 2: Rainfall, Vegetation, Geology and Average Maximum Temperature for Northern South Africa

SOUTH AFRICA	**Avg.Rainfall (mm)**	**Vegetation**	**Topographic features**	**Avg. Max Temp (deg C)**
Northern Natal (Maputa)	578	Coastal Grassland and Subhumid Lowveld Bushveld	Coastal planes	30
Mozambique border (Skukuza)	640	Sweet Lowveld bushveld	Low plateau & planes	30
Zimbabwe border (Messina)	371	Mopanie Bushveld	Ridges & planes	31
Botswana border (Ellisras)	357	Sweet bushveld	Ridges & planes	30

MEASUREMENT METHODOLOGY

Reflectance measurements in nature require a very specific measurement procedure. Firstly, before each measurement a reference measurement is taken, using a white standard. This is usually in the form of a calibrated target, made from barium sulphate or spectralon (type of nylon). The reference is placed in the same orientation and illumination of the object to be measured, in order to achieve measurement consistency. The white standard is used to correct the solar spectral conditions during the time of measurement.

Thereafter the object of interest is measured, and the measured spectrum is corrected, using the spectrum of the white standard. Each of the data points at every location is the average of a number of measurements in that specific region. In our case it can comprise of up to thirty individual measurements.

The CIELAB values of the corrected spectra are then calculated, in order to define the L*a*b*-values of the colour. Figure 3 shows a typical measurement site in South Africa.

Figure 3: Measurements in a typical Sweet Lowveld bushveld (Savannah) area

COLOUR DATA

The data, as published in Boyd's report, was plotted on the same graph as the data captured by us (Figure 4). The left-hand subplot represents the L*-axis, the right-hand subplot represents the a*b*-axis.

The L*-value is the lightness value, on the scale 100 being white and zero being black. The a*-values represents the green-red axis; values less than zero are green, values larger than zero are red. The b*-axis represents the yellow-blue axis: values less than zero are blue, values more than zero are yellow. In the type of measurements described here b* will not be less than zero.

On the L*-axis, the most left data-"tower" (triangular markers) are the South-African measured L*-data. Red triangles represent the values for grass, green for trees, blue for soil and purple for bark. Each of these data-points is the average of several measurements taken at various locations within a region. The solid triangles are the global averages (average for all measurements, all regions) for grass, trees and soil respectively.

The middle data-"tower" (square markers) represents Boyd's L*-data measured during the wet season (designated Aus1), while the right-hand data-"tower" (diamond markers) represents the L*-measurements for northern Australia's dry season (designated Aus2). Again, the red markers represent measurements for grass, green for trees and blue for soil. The solid markers represents the global average for all L*-values of the respective natural features measured.

The same rules as for the L*-subplot applies to the a*b*-data in the right-hand subplot.

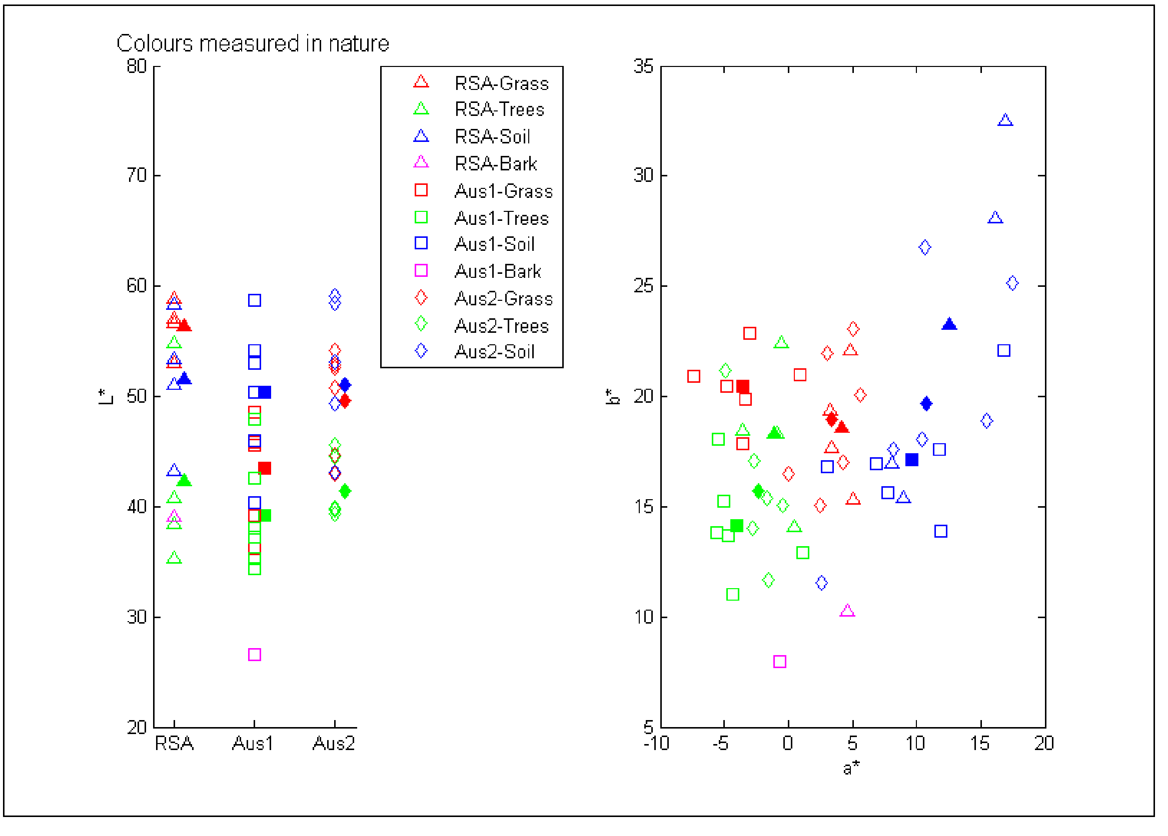

Figure 4: CIELAB Data for Northern Australia and South Africa

DISCUSSION

Table 1 and Table 2 provide a comparison between the South African- and Australian environments studied. The topography is mostly planes, ridges and plateau for both countries. The photographs published in the scientific reports [Boyd, 1995; Baumbach, 2004] confirm that the environments are very similar. The average maximum temperatures are very similar. Being in the middle of the landmass, a place like Ellisras receives marginally less rain than the driest part of Australia studied (Tom Price). Cairns in Australia gets three times more rain than the South African border with Mozambique. The lower rainfall in South African is also the result of being further from the tropics, and Madagascar (which is off the coast with Mozambique) tempers the effect any tropical cyclone might have on the country. The vegetation in the areas studied were mostly Eucalyptus in Australia (confirmed by the photographs published), while the South African environment studied is a savannah area classified as Bushveld, which is very diverse in terms of its plant growth.

The measured colours of the natural environment are plotted in Figure 4. Firstly the L*a*b*-values of grass (all red markers) for the two countries is compared. South-Africa's measurements were mostly done during the winter/early spring (dry season). Due to the low rainfall during the winter months the grass has very little green, and has a predominant beige/tan colour. This is clearly reflected in the data. L* is high, which means very light colours. The chromaticity data has only red and yellow components, confirming the beige colours observed in nature. Australia's wet-season measurements clearly show the green foliage (negative a*-values and positive b*-values), while the dry-season measurements are very similar to South Africa, except for lower L*-values. The chromaticity component for the average colour of winter grass in South Africa and Australia is for all practical reasons exactly the same. The colour difference (global averages for the two countries) in CIE delta E (dE) units is between 7 (dry season) and 15 (wet season). A dE unit of one is a just noticeable difference.

The average L*-data for trees in both countries is very close to each other (solid green markers). Compared to the South-African data, Australia's trees are greener and less yellow (larger a*-value, smaller b*-value). Boyd did most of the measurements in areas with predominantly Eucalyptus trees, as seen in the photographs published with his report. This was confirmed by the vegetation map shown in Figure 1 [Geoscience Australia, Jan 2009]. The colour difference (global averages) between the colours of trees in South Africa and Australia is 3 dE units for the dry season and 6 for the wet season.

The lightness value (L*) of the soils in both countries' sample areas shows striking similarity. The L*-values for all data is between 40 and 60, with the global average close to 50. However, the spread in chromaticity data (a*-b*) is larger than for the grasses and trees. The South-African soils are more yellow than the Australian soils. The colour difference is between 4 and 7 dE units.

Boyd and Baumbach only published bark measurements for one area. The South-African bark seems to be lighter and more red, compared to the Australian measurement. The Australian bark is very close to a neutral grey, with the a* and b* values zero and seven respectively. The colour difference is 14 dE units.

CONCLUSIONS

A comparison between the colours of grass, trees and soil for South Africa and Australia have been made. The areas studied have similar topography and average maximum temperatures. The biggest difference is the rainfall, with the South African areas receiving significantly less rain. The chromaticity channel of the colours of the grass (dry season) is for all practical reasons the same, the biggest difference is in the lightness channel. The colour difference is between 7 and 15 dE units. The trees in Australia are greener than those in South Africa, which is most probably the result of the higher rainfall in the Australian areas. The colour difference is between 3 and 6 dE units. The South-African soils are more yellow if compared to the Australian soils, with a colour difference of between 3 and 6 dE units.

In general, the data shows the colours of natural elements in South Africa are lighter than those in Australia. The data also shows that the South African colours are more chromatic than those measured in Australia.

This data could be used in a wide variety of applications. Firstly, in the military environment it could be used for the design of camouflage patterns. Although the actual pattern might not fit both environments equally well, the colours will at least be accurate. In the second place, this data might be of importance for the remote sensing community. The bluegum tree (*Eucalyptus* species) and the wattle (*Acacia* species) are native to Australia, but are considered as invasive species in South Africa. If this type of data is shared in a common database, detection of these invasive species, using remote sensing methods (e.g. satellite), could be done without extensive groundwork and data processing in order to capture the spectral signatures.

The colour data might also find application in the fashion and interior decoration environments. Because of similar colours in nature (as well as similar weather conditions) the population of the two countries might prefer the same colours in clothing and cosmetics. Paint schemes on houses and buildings (inside and outside) might also be very similar due to similar external environments. These two aspects might provide opportunities for counter-trade and colour trend prediction in products.

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