AERIAL ALBEDOS OF NATURAL VEGETATION IN SOUTH-EASTERN AUSTRALIA

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ABSTRACT

70 mm black-and-white low-level photography was used to record the track of the aircraft, which was then plotted on conventional 1:80,000 23 cm photogrammetric photographs and referenced against simultaneous measurements of the beam albedos of vegetation. Using steo-scopic pairs of the 70 mm photographs, the vegetation was classified into sub-formations. Marked differences in the'sub-formation'albedos were observed. A two-way table using stand height and crown cover of the sub-formations clearly showed a very distinctive trend of albedos. This finding may be important in other vegetal studies.

1. INTRODUCTION

Previously (Howard, 1970), a method for the stereoscopic profiling of natural vegetation from aerial photographs was outlined and a two-way aerial photographic classification of vegetation presented. This study was followed in 1972 in south-east Australia by the measurement of albedos of a range of major plant communities (i.e. formations/sub-formations, sensu Beadle & Costin, 1952); and included several sub-formations examined in the 1970 study. The results of the albedo study are presented in this paper.

2. METHOD

Albedo (L) is the fraction/percentage of incident solar radiation (S_i) which is reflected (Sr) from the earth's surface, including its vegetation. Beam measurement simply implies that the radiation is measured with a narrow-beam radiometer. In the present study, a thin glass twin-domed radiometer (Funk-type pyronameter) was mounted on the roof of the aircraft (i.e. Cessna 172, 182) for recording incident solar radiation in flight. A vertically downwards pointing beam instrument (4^o angular field) was mounted on a specially designed plate, external to the aircraft fuselage, for recording simultaneously the reflected solar radiation from the plant communities. The transduced signals from the radiometers were then recorded in millivolts on a Toa paper-chart recorder housed in the rear of the aircraft.

In order to calculate an albedo (L_b) from the aerial recordings, it was necessary to apply a conversion factor to the beam measurements. This conversion factor (C) was separately determined (see Howard & Barton, 1973) i.e. $L_b = \frac{Srb}{Si} \times C$.

In addition, a 70 mm format Vinten camera (fig. 2) was mounted alongside the beam shortwave radiometer, so that a permanent photographic record would be obtained of the vegetal surfaces being studied. The 70 mm aerial photographs enabled the track of the aircraft (and beam radiometer) to be plotted on small-scale photogrammetric photographs (e.g. 1/80,000) and, from this, an appraisal made of the ground areas covered by the plant sub-formations and their related albedos. All measurements were recorded under clear sky after several rain-free days and at a flying height of 330 m above ground datum. Each series of measurements across a plant sub-formation covered a distance of at least 5 km and frequently 50 km. Several of the sub-formations were covered on more than one occasion between 1100 hours and 1400 hours meridian time, March to August, 1972. At time of recording, the sun's elevation varied between

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25° and 40°. On the 22nd June (mid-winter), its maximum elevation was 28°.

3. RESULTS

The location of the plant sub-formations, above which the albedos were measured, are shown in fig. 1. It will be observed that measurements extend across mesic communities near the coast (144°E, 37°S), across mesic communities on the Great Dividing Range (145°E, 37°S) to communities in conditions approaching semi-arid to the north of the river Murray (143°E, 34°S). The numbers on the map are cross-referenced with Table A. Table A lists the sub-formations (Sensu Beadle & Costin, 1952) and provides information on solar irradiance (incoming short-wave radiation) and reflected solar radiation (out-going short-wave radiation). The table also gives the derived albedos and the mean albedos for each sub-formation. Each recording listed in columns 3 and 4 indicates a separate flight. The terms forest, woodland, shrubland and grassland correspond to Raunkiaers size classes (1934): megaphanerophytes, mesophanerophytes, microphanerophytes and nanophanerophytes/chamaephytes. Raunkiaer's size-classes provide a useful basis for the physiognomic classification of major plant communities recorded on aerial photographs.

Fig. 3 are copies at contact scale (1/4000) of photographs taken with the vertically mounted Vinten 70 mm camera at the time of the albedo measurements. From these photographs the crown cover percent of the woody vegetation can be measured and the approximate height of the woody vegetation determined by parallax bar measurements. In Table B the sub-formatinns, across which albedo measurements were recorded, have been classified on the basis of stand height and crown cover (sensu Howard, 1970a, 1970b) and their mean albedos from Table A also entered in the table.

4. DISCUSSION

An examination of the albedos given in Table A draws attention to the marked differences in the albedos of tall woody vegetation and grassland or land on which the tall woody vegetation is sparse (e.g. tree savanna). Short woody vegetation (e.g. blue bush, saltbush) has a high albedo, which is between the albedos of grazed and ungrazed grassland. Probably the low albedo of the two forest types is the result of the relatively very rough surface these present to the incoming solar radiation.

Table B is of considerable interest. The albedos entered in this table show a distinctive trend and provide order to what in Table A may appear to be disorder. For the megaphanerophytes (forest), the mean albedos increase from .079 for wet sclerophyll forest to .105 for open dry sclerophyll forest. For mesophanerophytes (woodland), the trend is from .098 (tall woodland) through .116 (cypress pine woodland — Callitris glauca France) to .165 (Tree savanna). For the microphanerophytes (shrubland) and nanophanerophytes/chamaephytes mean albedos increase from 0.96 for Big Mallee to .140 for saltbush (Altriplex vesicaria) and to .155 for bluebush (K. pyramidata, K. sedifolia).

The high mean albedos of the nonophanerophytes and chamaephytes possibly provide an explanation for the increasing albedos of the megaphanerophytes and mesophanerophytes with the decreasing crown cover of the dominant woody strata. As the tree cover decreases, so the herbaceous ground cover becomes more exposed to incoming solar radiation and therefore contributes more to the reflected solar radiation of the plant community. Even grazed grassland has a high albedo (.135); but the albedo of ploughed land is lower (1.07). However, the micro-structure of ploughed soil is rough. Water has a very low albedo (.018) and this is seen as contributing to the low albedo of swamp (.060). The albedo of water was observed to vary with colour (i.e. sediment content), but is not reported on here as it requires a separate study. Whether a wide range of structural types of vegetation can be identified by their albedos needs further investigation. An examination of table A shows that, although the mean albedo (Lb - column 6) may be distinctive for some of the sub-formations, there is often an overlap of their albedos (L_b, column 5). The overlap of dry sclerophyll forest and tall woodland is not surprising, since the criteria of height and crown cover or height and crown diameter often give conflicting field classifications. The similarity of the albedos of dry sclerophyll forest, tall woodland and big mallee, occurring under quite different climatic regimes, is interesting and suggest some unidentified unifying factor. Each are communities of dominant eucalypts; and, perhaps, this is associated with their leaf area indices. Wet sclerophyll forest and shrub woodland, the only other eucalypt dominant communities are distinctive from these by their well developed woody under storey.

The orderly sequence of albedos, when placed in a two-way photo-phsiognomy table (Table B) draws attention to the importance of size class/dominant height and gross cover of the ground by woody vegetation as parameters influencing the albedos of natural surfaces. The photo-physiognomie table per se was developed previously by the author (Howard, 1970a, 1970b) as means of classifying vegetation in Australia directly from aerial photographs and as such has been extended to the vegetation of East Africa (Howard, 1970a). The logical fit of the albedos into the vegetal table is also seen as emphasizing the usefulness of this kind of table for classifying vegetation from aerial photographs and implies, perhaps, that albedos as recorded on satellite imagery could be used as a basis to vegetal classification.

5. ACKNOWLEDGEMENT

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TABLE A — Major plant sub-formation, their reflected radiation and albedos and solar irradiance — S.E. Australia, 1100-1400 hours. March/August 1972.

Map no.	Plant sub-formation	Solar Irradiance $mWcm^{-2}$ (si)	Reflected Radiation $mWcm^{-2}$ (Sr)	Beam albedo (Lb)	Mean albedo (Lb)
1	Wet sclerophyll Forest	51,74,83	4.8,6.1,5.1	.094, .082, .062	.079
2	Dry sclerophyll Forest Dividing Range	53,73,85	4.8,6.4,7.6	.091, .088, .089	.090
3	Dry sclerophyll Forest Riparian — with moira grass	65,65,64	7.4,6.1,7.9	.114, .093, .108	.105
4	Big Mallee	57	5.5	.096	.096
5	Savanna Mallee	66	6.6	.100	.100
6	Tall Woodland	54	5.3	.098	.098
7	Cypress pine Wooland	31,71,54	4.0,7.2,5.3	.133, .101, .098	.116
8	Shrub Woodland	33,34	4.1,4.3	.124, .126	.125
9	Tree Savanna	66	10.0 to 11.8	.151 to .179	.165
10	Steppe (Saltbush)	59,67,62	8.9,9.2,9.7	.150, .137, .134	.140
11	Steppe (Bluebush)	66,67	10, 10.6	.152, .158	.155
12	Grassland (Native ungrazed)	56	8.7	.155	.155
13	Grassland (grazed)	57	7.7	.135	.135
14	Water	76	1.4	.018	.018
15	Swamp (Murray red gum)	57	4.1,3.0	.064, .057	.060
16	Bare ground: Ploughed (dry reddish brown soil)	74,69,55	7.4,6.9,6.6	.100, .100, .120	.107

TABLE B — Two-way photo-physiognomic classification of woody vegetation using dominant height and gross cover of the woody vegetation. Albedos shown in brackets.

Life form	Megaphanerophytes	Mesophanerophytes	Microphanerophytes	1 Nanophanerophytes 2 Chamaephytes
Size class - Raunkiaer (Height - M)	30	8.30	2.8	1 0.25-2.0 2 0.25
Gross cover (dominant woody strata) c. 100%	Wet sclerophyll Forest (.079)			
Very dense e.g. 75%	Dry sclerophyll Forest (.090)	Tall woodland (.098)		
e.g. 10-50%	Dry sclerophyll Forest (.105)	Cypress pine woodland (0.116) Shrub Woodland (.125)	Shrubland Big Mallee (.096) Savanna Mallee (.100)	Steppe. Saltbush (.140) Blue bush (.155)
Open e.g. 10%		Tree Savanna (.165)		Grassland (.155)

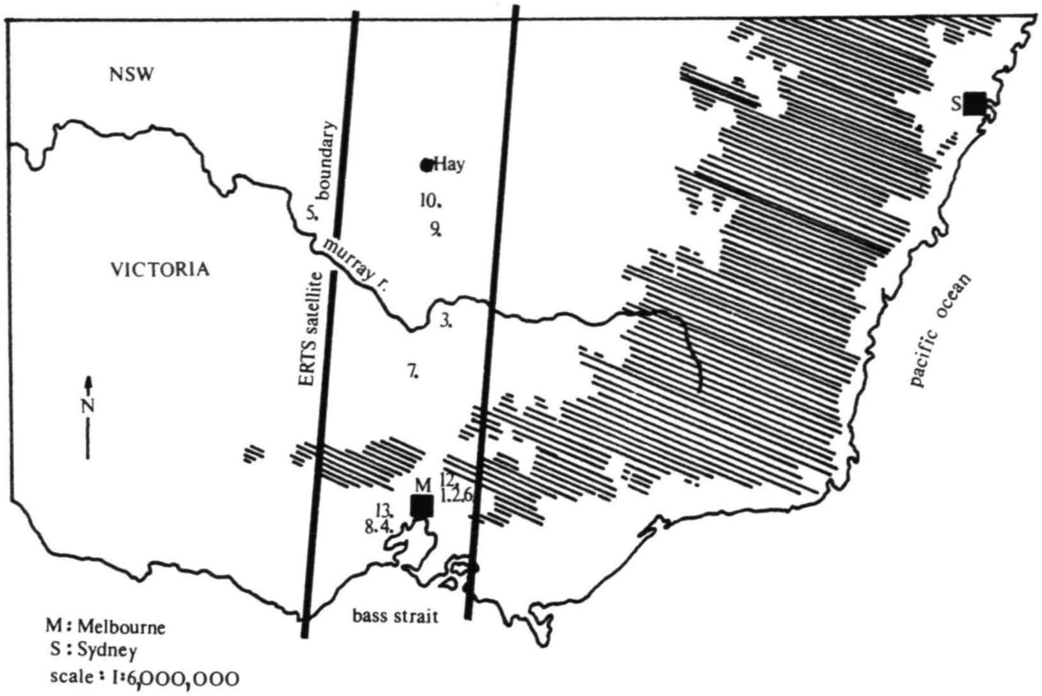


Fig. 1. Map of south-eastern Australia showing the location of the albedo sampling areas (cf. Table A).

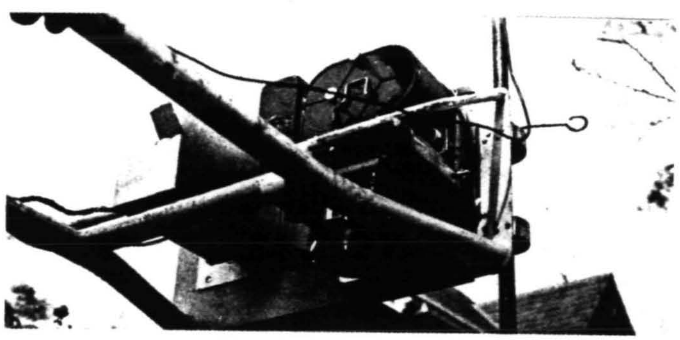
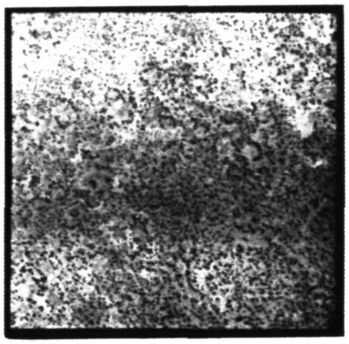
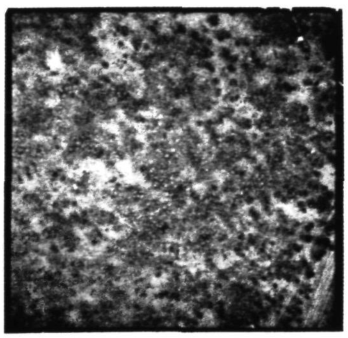


Fig. 2. Short-wave beam radiometer and 70 mm camera used on plate external to aircraft fuselage.



(A)

(B)



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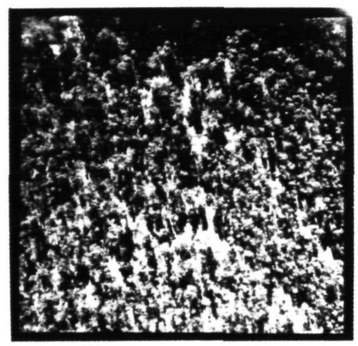

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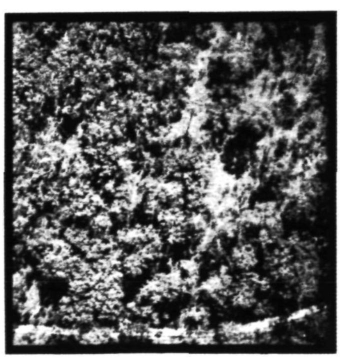

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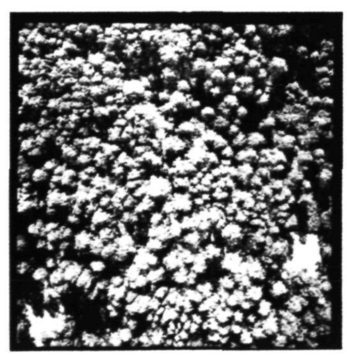

(F)

Fig. 3. 70 mm vertical aerial photographs of plant sub-formations over which albedos were measured. (a) Steppe - saltbush (b) Shrubland - mallee (c) Woodland - Callitris glouca (d) Woodland - shrubs and small trees (e) Forest - dry sclerophyll (f) Forest - wet sclerophyll