APPENDICES

APPENDIX A

NOTES ON THE SOILS AND VEGETATION OF THE PILLIGA STUDY SITE

Mapping

At a small-scale, the soils of the area covered by the Pilliga State Forests have been mapped as either a single unit (Stephens, 1961) or a few broad-based units (Northcote, 1966). Stephens (1961), at a scale of 1:5 000 000, mapped the area as solonetz and solodised-solonetz soils (Great Soil Groups). Northcote (1966) divided the area between three units (at a scale of 1:1 000 000); sandy solodised soils in the south east (Gn2.2, Northcote 1965); sandy soils with mottled yellow clayey subsoils (Dy5) and associated solodised (Dy5.42) and solodised-solonetz (Dy5.43) soils in the central region; and sandy soils with mottled yellow clayey subsoils associated with solodised-solonetz (Dy5.43) soils in the west.

The Soil Conservation Service of New South Wales (1978) mapping at a scale of 1:250 000, produced the Narrabri Soil Landscape map, mapping the northern area of the Pilliga Forests only. This unit (ES) comprised low dissected ridges where sandy solodic soils dominated, but where deep siliceous earths, earthy sands, lithosols and red and yellow earths were also to be found (Great Soil Groups after Stace *et al.*, 1968). The sandy solodic soils were described as sandy, acid, with a distinct but not particularly heavy mottled B horizon of clay or sandy clay and a bleached A2.

The soils have also been examined from an agricultural point of view by Jensen (1912, 1914), Waring (1950), Stephens (1953), Warburton (1956), Davidson (1964), Clough (1969), Curtis (1975) and Hubble and Isbell (1983). The consensus is that the soils of the area are infertile, prone to erosion and unproductive.

Studies relating to the genesis of the soils in the region have been undertaken by Waring (1950) and Hallsworth and Waring (1964) and a land system survey of the Pilliga (Mitchell *et al.*, 1982) discussed patterns of landform, soils and vegetation.

History

Dodson and Wright (1989) examined the climatic changes during the Quaternary which influenced vegetation on the Pilliga Sandstone. They concluded that vegetation around 30,000 yr B.P. was probably similar to that existing today. A vegetation shift to a semi-arid shrubland followed, probably representing a decrease in rainfall from 600 to 300 mm/yr. This shift reached a peak between 25,000 and 10,500 yr B.P. During the Holocene the modern vegetation cover of forest and heath was established.

Rolls (1981) considered that before European settlement the forest comprised a mosaic of open woodlands and grassy plains maintained by Aboriginal burning. There are a few sites near main creeks which point to the presence of the Kamilaroi aborigines presence in the forest; however, very little archaeological research has been undertaken. The sequence of events after European settlement discussed by Rolls has been questioned by Norris *et al.*, 1991, particularly the timing of regeneration events and the extent of the forest actually occupied by Europeans. Survey maps of the 1870s and 1930s show vegetation boundaries which coincide with those found today, and examination of records shows the settlers along the waterways may never have penetrated the core of the forest. The evidence for stability in the vegetation patterns in the study area and the relevance of this will be discussed below.

In the late 1800s the area was largely Crown leasehold land, and the timber industry in the Pilliga began in about 1880 with the cutting of ironbark (*E. crebra*) for railway sleepers (Forestry Commission, 1986). The cypress pine (*Callitris* spp.) was also cut for fencing and building. There has been a decline in production in recent years.

The soil stratigraphy of the main field area

A-B on Figure A1 (location shown on Figure 3.2) is a stratigraphic section along Dunwerian Road from west to east through the broom plains and mallee. It shows a preliminary interpretation of the relationships between soil materials and the underlying substrate.

Layer 1 is the topsoil which ranges in depth from 15 cm upslope to 50 cm downslope. It is divided into Layer 1i (A1) and 1ii (A2). Layer 1i is an organic sandy loam containing charcoal and quartz gravel. It has an earthy fabric. Layer 1ii varies from a thin, conspicuously bleached cemented layer (1iia) overlying domes in sandstone derived subsoils (in the mallee), becoming a thicker bleached layer (1iib) with an earthy fabric where no domes are present through a sporadically bleached layer (1iic) where the underlying sandstone is deeper (in the upper broom plain) or where alluvium is the substrate (in the lower broom plain). Topographically lower, over alluvium subsoils, the layer becomes unbleached and very thick (1iid). It is proposed that Layer 1 is a contemporary mobile layer, the genesis of which is similar to that of the topsoils discussed by Humphreys and Mitchell (1983).

Layer 1 passes over two subsoils. Layer 2 comprises Pilliga sandstone (2ii) and this sandstone weathered *in situ* to a harsh, sandy clay subsoil (2i). The upper part of the slope is in the conglomerate facies of this sandstone. Where the overlying topsoil is thin, in the up-slope position under mallee vegetation, Layer 2i forms domes and the

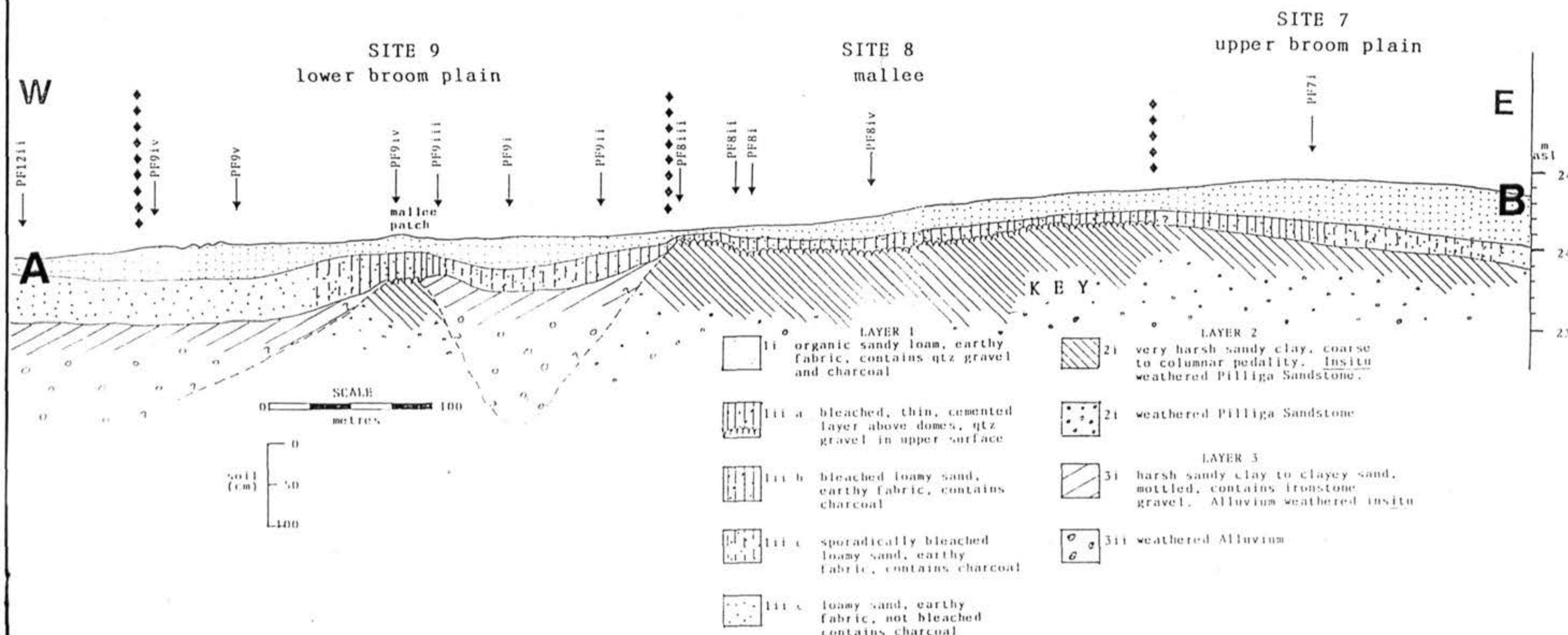


FIGURE A1: Stratigraphic section A-B along Dunwerian Rd., showing relationships between soil materials, Sites 7, 8 and 9. Vertical exaggeration 10X.

pedality is described as columnar. Where the topsoil is deeper the domes disappear or become sporadic in occurrence. Examination of a patch of mallee vegetation in the middle of the lower broomplain confirms that the presence of sandstone derived subsoil underlying a shallow topsoil is correlated to the presence of both a thin, cemented Layer 1iia and the doming of the subsoil. The mallee vegetation appears to be related to these features in the soil.

Layer 3 is weathered alluvium which contains varying amounts of clay and sand as well as ironstone gravel lenses. The resultant subsoil (3i) ranges from a harsh sandy clay to a harsh clayey sand. The overlying topsoil is deep.

Water moves over the top of the subsoils through Layer 1ii. Perched water tables are common in this layer. Where impeded by the clay rich sandstone derived subsoil, Layer 1ii developes a conspicuous bleach. Where the water has opportunity to drain vertically as well as laterally (over alluvium derived subsoils for example), the bleach is sporadic. All soils are solodic in nature.

Evidence for vegetation stability

The boundaries between each of the vegetation communities making up the field site are very sharp (Plates 12 and 15). It is important, in a project which is to examine relationships between communities and the sediments on which they grow, that the vegetation patterns are stable through a defined period of time. Thus it becomes important to establish a minimum period of time during which the boundaries have not changed.

The modern vegetation on the Pilliga Sandstone is believed to have become established at the beginning of the Holocene (Dodson and Wright 1989); however we only have records for the past 200 years and can only argue for stability over the period of that time where we have actual maps. The earliest portion plans in the Dunwerian Parish (Lands Department, 1878) have written on them notes about the vegetation which, when the portion is located, is the same today. Figure A2:A is a tracing from a topographical survey conducted in 1914 (Gambert, 1914) while Figure A2:B and C are tracings from air-photographs taken in 1938 and 1970. All show the study area; and it appears that the vegetation boundaries have been stable at least during this century and probably for some time before this.

The Surveyor for the 1914 survey was Frances Gambert. His annotation on the broom plains reads:

> "Undulating country with low flat ridges consisting mostly of fair very sandy loamy soil with scattered patches of poor loose raw sand and occasional gravelly patches stony and gravelly in places and occasional rocky outcrops on ridges.
> Covered with dense scrub consisting mostly of Broom with scattered patched of Heath Ti-tree, Grass Tree, low scrubs of various kinds and occasional patches of Ironbark seedlings, Curracabar Wattle, Mallee and Umbrella Bush, very scattered Ironbark (mostly dead,) Pine, Gum Apple and Bloodwood. Large proportion has been burnt by bushfires and is now regrowing." (Gambert, 1914).

The vegetation referred to is probably *Melaleuca sp.* (broom), *Leptospermum flavescens* (heath ti-tree), *Xanthorrhoea sp.* (grass tree), *Acacia cunninghamii* (curracabar [*sic*] wattle), *A. oswaldii* (umbrella bush), *Eucalyptus tessellaris* (bloodwood [Carbeen]), *E. crebra* (ironbark), *Angophora costata* (gum apple) and *Callitris columellaris* (pine), all of which are found in the area today in the places indicated by Gambert.

A distinctive vegetation community, the casuarina, occupying gilgai areas, is mapped in the same position it occupies today, as is the box community surrounding it.

Gambert also made notes on the soils he found. Areas of thick wattle and hopbush (*Dodonaea sp.*) near Pine Road are noted as having

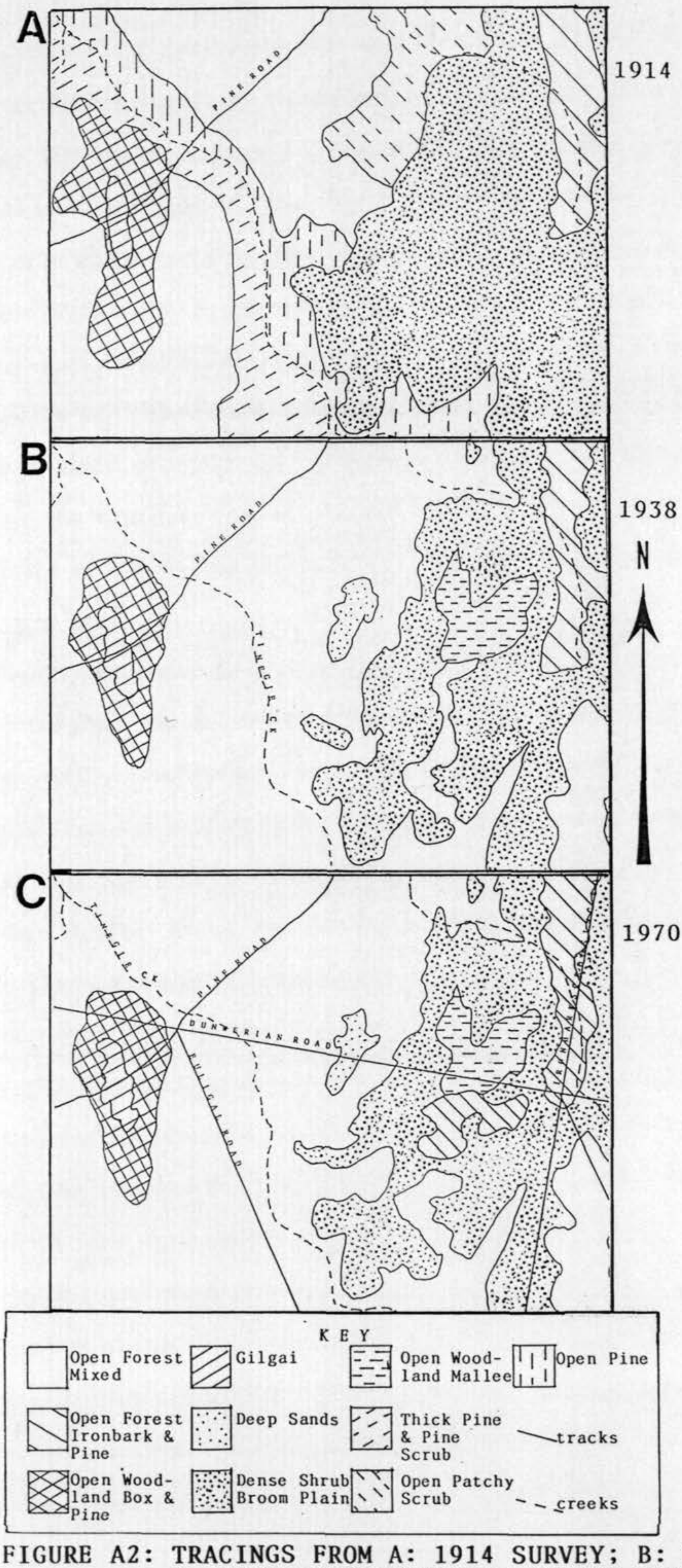


FIGURE A2: TRACINGS FROM A: 1914 SURVEY; B: 1938 & C: 1970 AIRPHOTOGRAPHS OF THE STUDY AREA "red loam soil, clayey subsoil"; to the north of Pine Road the soil is a "Good stiff organic soil, clayey subsoil". Another comment which often appears is related to fire , for example "Good patches of thick Wattle & Hopbush partly killed by bush fires" (near Pine Road).

The airphotographs show little change in vegetation boundaries between 1938 and 1970, and the comparison with the boundaries shown in the survey is also remarkably good, a credit to the skill of the surveyor given the extremely dense vegetation through which he had to pass! A stand of burwinged wattle (*A. triptera*) is enough to convince all but the hardiest to find another path.

The soils of the Mallee (Site 8)

Solonetz, solodised solonetz and soloths are a series of soils which are considered to show progressive leaching of all free salts (solonization) and exchangable sodium and magnesium (solodisation) (Paton 1978). Duchaufour (1977) discussed the current ideas on solonisation and solidisation. He divided these soils into two types; the saline type with no alkalinity, sodium chloride (and perhaps also sodium sulphate) being the sodium ions present, and the alkaline soils where the exchangeable type of sodium is sodium carbonate or bicarbonate, which raises the pH to over 8.5. This group included the solonchak-solonetz, which are massive; the solonetz which are differentiated into silt/clay; and the soloth or solod where the pH rises down the profile from 5 to 7 to 9. What is required for these soils to form is a source of sodium ions, either groundwater or weathering rock minerals, dry climate and a topographic depression. Duchaufour states that the rounded tops of the columns are covered with a deposit from the movement of amorphous organic compounds, (sodium humates) and dispersed clay covered by a "pulverescent siliceous residue" (1977:434).

In an early classification of Australian Soils, Prescott (1931), called these soils Mallee Soils since they were typically associated with mallee vegetation. He commented that the Mallee Soils were usually alkaline (pH 7.5 to pH 9.5) although more acid and more alkaline soils were known. Their genesis was related to "the accession of cyclic salt, the low leaching effect of the rainfall and by the action of the wind in building up sandhill formations." (1931:62).

Downes and Sleeman (1955) surveyed the soils of the Macquarie Region, New South Wales. While not covering the Pilliga Region, this soil survey covered an area to the south of the Pilliga not unlike the area covered in this thesis. A large part of the area consists of alluvium, including the coarse sandy material derived from the Jurassic bedrock. Soils discussed in the survey included the solodized solonetz which were to be found in the drier areas of the Coonilliga Combination. Downes and Sleeman commented that in this unit, variations between the soil series of the major soil groups were found; the sandy solodised soils, sandy solodic soils and the solodised solonetz, appeared to be correlated with the sequences of the underlying beds exposed by dissection. Some soils contained iron impregnated sandstone sheets up to an inch thick which appeared to be of geological origin (1955:29).

The genesis of the soils was explained in terms of the effect of changes in climate on old land surfaces. Indirect effects were stated include the possible accumulation of cyclic salts during the Recent arid period. With the onset of wetter conditions, solonisation, and later if there was sufficient leaching, solodisation occurred.

Hallsworth, Costin and Gibbons, (1953) classified the solodic soils into four groups; the solonetz, solodised solonetz, solodic and solod. This classification was extended by Thompson and Paton (1966) to encompass two groups each of three soils. The first group had a columnar structure and was alkaline throughout (solonetz), alkaline in the lower part of the profile (solodised solonetz) or acid throughout (columnar soloth). The second group had a blocky-fine prismatic structure (not columnar) and was alkaline throughout (blocky solonetz), alkaline in the lower part of the profile (solodic) or acid throughout (soloth). The soils examined in this thesis fall into both groups - i.e. may or may not be columnar in subsoil structure, and have acid topsoils which, in some cases, become neutral to alkaline in the subsoil. Thompson and Paton commented that:

> "The characteristic features of many of these soils may be due to processes other than those of the classical leaching sequence of solonchak to soloth. The initial texture contrast in many cases may be due to the deposition of sandier materials over clay remnants of other soils, and the chemistry of the resultant soil largely determined by that of the inherited clay" (1966:2-2).

Hallsworth and Waring (1963) put forward "An alternative hypothesis for the formation of the solodised-solonetz of the Pilliga district". The authors quoted the classical theory of Gedroiz, 1928, concerning the leaching of soluble salts which have accumulated under hot arid conditions. When a change in climate, (increased effective rainfall) or a fall in groundwater occured, a series of related soils was formed; the saline soil (solontchak), the alkali soil (solonetz) and ultimately the acid soil (solod). The intermediate stage, the solodised-solonetz, had acid upper horizons, calcium carbonate and a "cobblestone structure" in the B (1963:159). Hallsworth and Waring consider that these soils as they were found in the Pilliga area were in a topographic and areal relationships which made "the classical theory untenable" (1963:159).

The parent material for the soils was found to be the Jurassic sandstone. Four types of solodised-solonetz were recognized; two occurring on "laterite" residuals (the Newell S. L. on the indurated zone, the Talluba S. L. on the pallid zone) and the other two, the Yarrie and Merriwindi S. L. on the extensive areas of alluvium. All soils were sandy loams over clays and had a bleached A2, and lower sites displayed varying indurated layers. Two other complexes of soils were discussed; the clay soils which included the gilgai soils, and the Moongie sand which was found on the sand monkeys.

When discussing the pH trends exhibited by the soils, it was commented that the Merriwindi S.L., a solodised-solonetz, was usually acid throughout the B horizons; pH not rising until the C which is unusual in a solodised-solonetz. Soil descriptions given were fairly ordinary with colour, texture and occasional indication of fabric. Topographic relationships between the soils were given but stratigraphic relationships were not examined. The solodised-solonetz of the Pilliga district were not found to occur in depressions but on a slight but definite slope, typically away from depressions, as indeed were those in the field area covered in this thesis.

Halsworth and Waring discussed several theories which exist for the accumulation of salt in such areas including derivation from a buried stream cut in older sediments, for which there is no evidence. The main theory discussed was the accumulation of cyclic salt. There are no salt lakes within 300 miles (500 km) of the Pilliga from which large quantities of salt could be derived. They discussed the quantity of soluble salts which would be required to accumulate in the soil in order to produce a solontchak which, upon leaching, would produce a solonetz (240,000 lbs/acre, requiring some 84,000 years assuming present rainfall) and quoted Bonython (1956) who showed that 3,000 years was all that was neccessary to accumulate the salt in Lake Eyre. Calculations based on the amount of chlorine now present in the B horizons of the Pilliga soils show an amount which could have accumulated at present rates of accretion in 3,000 years, therefore it is not necessary in the authors' view, to invoke climatic change to explain a required accumulation of salt since it is probable that the material was never a solontchak. However, this needs to be re-evaluated in the light of more recent work on climatic change in Australia.

The authors put forward an alternative mechanism to account for the formation of the solodised-solonetz. This involves sediment containing a little silt and clay being layed down in floods. This small quantity of silt and clay was then moved through the coarser textured material. Experimental work by Hallsworth (1963) in artificial soils provided evidence that with the successive in-washings of clay the clay content of the B horizon would rise until it reached 40% when this process would stop. Since the composition of the exchangeable ions in the clay would be high in sodium, the material would tend to shrink and swell, form the colomnar structure, and gradually the B would become impermeable, leading to waterlogging of the A2.

However, the question of what happened to the clay after this point was reached is not clearly addressed. It is not clear whether they consider that this all took place during a more humid period, or under the present climatic conditions. If the later, then the washing of clay and silt into the soil must still be going on, and if it is not accumulating in the A horizons, it must be washing out laterally over the top of the B.

The pinky-white deposit found above the B horizon the authors considered to be plant opal and to provide the evidence to substantiate their genesis theory. If plant opal could be washed into the profile and accumulate against the barrier of the B, then so could fine silt and clay.

The paper was written at about the time that there was a great interest being shown overseas in phytoliths. An analysis of fresh leaf samples from the area was given and all quantities were consistent with work done elsewhere. Opaline silica was examined by wet oxidation of leaves, and the resultant opaline material was found to be mainly 0.0025 mm in diameter. The fine silt fraction of the soils was also examined and found to comprise mainly silica particles. On this unquantified evidence the authors stated that "It seems probable " that the material on top of the B is plant silica (1963:175). No examination of the A or B horizons are reported to have been done. This paper has been quoted by subsequent authors as providing evidence of the mobility of plant opal in some soils (Kalisz and Stone, 1984).

The formation of the duplex soils in the Pilliga

The yellow solodic soils of the Pilliga Region are classified as either columnar soloths if they possess columnar structure such as the soils of the Mallee, or soloths if they do not (Thompson and Paton, 1966) if they are acid throughout the profile. Those which have an alkaline subsoil are solodised-solonetz or solodics. They are all duplex soils (Northcote, 1974) or harsh texture contrast soils (Paton, 1978).

In view of the recent work on the genesis of texture contrast soils (Paton, 1978; Bishop *et al.*, 1980; Humphreys and Mitchell, 1983; Humphreys, 1985; Mitchell, 1985; Mitchell and Humphreys, 1987), the above model for soil formation in the Pilliga is open to question. Bishop *et al.* (1980) showed that the texture contrast soils on hillsopes in the Sydney Basin were formed by the transgression of a mobile sandy layer over *in situ* weathered rock. The mobile sandy topsoil was formed by a combination of bioturbation by ants and termites, etc., bringing soil material to the surface, and rainwash removing the fines (Humphreys and Mitchell, 1983; Mitchell and Humphreys, 1987). Where the mobile sandy topsoil moved over subsoils formed from differing parent materials, investigation of the soil stratigraphy demonstrated that the topsoil was a separate layer. Where the sandy topsoil passed over clayey subsoils, texture contrast or duplex (Northcote, 1974) soils formed; where it passed over rock or sandy subsoils, uniform soils formed.

Similar stratigraphic relationships have been demonstrated in the field site (Figure A1). Layer 1 (the mobile sandy topsoil) was shown to be present over subsoils formed *in situ* from two differing parent materials, sandstone and alluvium. The mechanisms for generating the sandy topsoil have been discussed in the mesh bag experiment of Chapter 8, where it was shown that soil fauna were bringing material to the surface and placing it on top of the litter. Thus the model for texture contrast soils described above can be evoked for the genesis of the texture contrast soils in the Pilliga field site. These are the harsh texture contrast soils of Paton (1978).

Soil fauna, including ants and termites, bring material to the surface, where clay is selectively removed in rainwash, leaving behind the coarser materials, thus giving rise to a coarse textured A horizon, the depth of which depends on the species of fauna and where they operate. Humphreys (1981) found that the activities of ants and earthworms near Sydney in the upper 30 cm of the soil would turn over the soil to this depth in about 430 years. Humphreys and Mitchell (1983) considered that the combination of bioturbation turning over the soil and rainwash removing the fines in a material having a non-uniform grain size would lead to the development of duplex soils. They envisaged this as part of a continuum of effects leading to the development of Uniform, Gradational and Duplex soil profiles (Northcote 1974) and consider the model applicable to "a very wide range of contemporary environments" (1983:77).

The Pilliga is just such a contemporary environment. While a detailed investigation into the genesis of the texture contrast soils in the study area was outside the scope of this thesis, the finding that the termite activity in building sheeting alone was sufficient to turn over the soil to the depth of 10 cm in 261 years (Site 8, the mallee), 306 years (Site 7, the upper broom plain) and 1,014 years (Site 12, the forest). These figures are for the one activity - if the mounding by ants and termites in the area was also taken into consideration the process would be considerably speeded up, however this alone is sufficient to demonstrate that similar bioturbation processes are occurring here as at Humphrey's and Mitchell's sites.

Rainwash has not been measured at the Pilliga sites; however, the decay of ant and termite mounds during rain has been observed. The processes leading to the development of texture contrast soils on sandstone in the Sydney area can be seen to be equally effective in the Pilliga on sandstone to produce a similar texture contrast. Eluviation and illuviation need not be considered as a playing a part in the genesis of the soil.

APPENDIX B

SOIL PROFILE DESCRIPTIONS

Soil Profiles described for this thesis are presented here. They are grouped according to site, and each is given a soil profile identification comprising location, site and profile number. The location indicators are:-

Oxford Falls	-	OF
Pilliga State Forest	-	PF
Macquarie University Ecology Reserve	-	ER

The climate actual Location of each soil profile is to be found on the map in the relevant Chapter of the thesis.

For each profile the following information is given: method of sampling (i.e. from auger hole, soil pit), landform element, a brief vegetation description (expanded in Appendix C), land use, bedrock, drainage and any other relevant information.

Profile descriptions are made using standard terminology as suggested in the Australian Soil and Land Survey Field Handbook (McDonald, Isbell, Speight, Walker and Hopkins, 1984) and in Northcote (1974). A Japanese Colour book (Oyama and Takehara, 1970) was used to determine colour, and a CSIRO pH kit (Inoculo Laboratories, Victoria) was used to determine field pH. Each profile has been classified according to Northcote (1974) Principal Profile Form (PPF).

In addition to standard methods, the identification of each material in terms of soil layers is also made (see Appendix A).

PILLIGA STATE FORESTS PROFILES

Location: Pilliga State Forests, located on Topographic Map Cubbo, 8736-N first edition 1;50 000 series. AMG reference is in zone 55. The sites are located along Dunwerian Rd, from Junction Rd (711500mE 6605800mN) to Pine Rd (708000mE 6610400mN), numbered from east to west, with distances measured from Junction Rd. in meters. Figure 3.2 gives the location of each site, and Figure A1 their stratigraphic relationships.

Vegetation: See Appendix C which lists the vegetation for each of these sites

Land use Logged native forest.

Site Location:	350m	Sampling:	auger hole
Slope:	level	Morph. type:	flat adjacent to creek
Substrate:	alluvium	Vegetation:	tall open-forest
Drainage:	well drained	PPF	Uc 4.24

Layer	Horizon	(mm)	Description
0	01	surface	Leaf litter, single grain sand, no crust, many ant mounds, cracks 1-5mm wide.
1i	A1	0 - 150	dark brown sandy loam, 7.5YR 4/3d, 3/4m, earthy fabric, organic, many roots binding together, some large chambers, ants and termites, cracks from surface 1-5mm wide. pH 5.5, clear and even to
1i	A12	150 - 250	grayish brown sandy loam, 7.5YR 5/2d, 3/4m, coherent earthy fabric, appears to be many faecal pellets, charcoal, pH 6.5, clear and wavy to
3i	B2	250 - 500	clayey sand, harsh, rounded gravel through out, grayish brown 7.5YR 4/2m. Rounded quartz pebbles v common (20%), 2-6mm diameter, layer of quartz gravel at 500mm, pH 6.5, gradual to
3i	B3	500+	continuing clayey sand

Site Location:	700m	Sampling:	auger hole
Slope:	gently inclined	Morph. type:	hillslope
Substrate:	Pilliga Sandstone	Vegetation:	broom plain
Drainage:	impeded at top of B	PPF	Uc 4.21

Other comments:burnt in 1951

Layer	Horizon	(mm)	Description
0	01	surface	litter of *Melaleuca* sp. leaves, often bound together by lichen into a mat, very moist site
1i	A1	0 - 200	loamy sand, organic, earthy fabric, much fine quartz gravel through, some charcoal, brownish black 10YR 2/3m, 4/4d, many ant chambers, pH 5.5, clear to
1iid	A2	200 - 300	loamy sand, dark brown 10YR 3/4m, no gravel but contained some charcoal, pH 5.5, clear to
1iid	A3	300 - 500	loamy sand, some fine quartz gravel and charcoal, yellowish brown 10YR 5/6m, pH 6.5, gradual to
2i	B2	500 - 800	clayey sand with charcoal, yellowish brown 10YR 5/8, pH 6.5, gradual to
2i	B3	800 - 1000	mottled clayey sand, no charcoal, pH7.0, gradual to
2ii	C	1000+	weathered sandstone

PF3i

Site Location:	1,100m	Sampling:	auger hole
Slope:	upper slope, v gently inclined	Morph. type:	ridge
		Substrate:	iron-rich sst/conglomerate
Vegetation:	tall open-forest		
Drainage:	impeded at top of B	PPF	Uc 5.21

Layer	Horizon	(mm)	Description
0	01	surface	single grain sand, litter
1i	A1	0 - 50	brown, 7.5YR 4/3m, 5/4d organic loamy sand (coarse) a little rounded quartz gravel, fine charcoal. Earthy fabric, bound by roots, many ant and termite galleries, pH5.5, gradual to
1i	A12	50 - 200	as above but more compacted fabric, gradual to
2i	B2	200 - 400	brown, 7.5YR 4/4m, 5/3d, coarse clayey sand. Contains coarser gravel and some charcoal, pH 5.5, gradual to
2ii	C	400 -600+	weathered sandstone

Site Location:	1,400m	Sampling:	pit
Slope:	v gently inclined	Morph: type:	mid slope
Substrate:	Pilliga Sandstone	Vegetation:	tall open-forest
Drainage:	impeded at top of B	PPF	Dy 5.42

Layer	Horizon	(mm)	Description
0	01	surface	v moist, thick litter, polygonal cracks 1-20mm
1i	A1	0 - 20	fine powdery sandy loam, very organic, many ant and termite galleries, cracks from surface. Dark brown 10YR 3/3m, 5/2d. pH 5.5, clear even to
1i	A12	20 - 50	dark brown 10YR 3/3m, 5/2d sandy loam, few v.small qtz pebbles, charcoal, bound with roots, earthy fabric highly bioturbated, sharp irreg. to
1iia	A2cb	50 - 300	grayish yellow-brown 10YR 5/2m, 7/2d sandy loam, contains few qtz pebbles, some charcoal, highly bioturbated, pebble layer, qtz 2-10mm diameter, imbedded in upper surface. Forms domes over clay layer beneath, very hard, massive, fills cracks which extend down into the B horizon at a spacing of 50cm. pH5.5. Tongued boundary to
2i	B2	300 - 500	mottled brown (10YR 4/4 [main]), dull yellowish brown (5/3), yellowish brown (5/8) and brownish gray (4/1) v. sandy harsh clay, resists shearing, columnar structure, pH 6.0, gradual to
2ii	C	500+	weathered sandstone

Site Location:	2,100m	Sampling:	pit
Slope:	very gently inclined	Morph. type:	lower slope
Substrate:	clayey sandstone	Vegetation:	broom plain
Drainage:	impeded at top of B	PPF	Dy 5.42

Other Comments:burnt 1966/67

Layer	Horizon	(mm)	Description
0	01	surface	v moist, thick litter, no surface cracking, mat of *Melaleuca* sp. litter bound together by lichens
1i	A1	0 - 100	brown 7.5YR 4/6m loamy sand, some organic material, v few roots, qtz gravel, charcoal, not as bioturbated as last site, some ants, pH 5.5, clear even to
1i	A12	100 - 200	brown 7.5YR 4/4m loamy sand as above, pH 5.5, clear even to
1i	A13	200 - 500	bright brown 7.5YR 5/6m loamy sand containing charcoal and quartz gravel, pH 5.5, clear to
1iia	A2cb	500 - 600	dull brown 7.5YR 6/3m, 7/1d bleached very moist clayey sand covering domes, some charcoal, pH 6.0, irregular to
2i	B2	600 - 700	mottled brown (10YR 4/6 main), bright yellowish brown (6/8), bright reddish brown (5YR 5/8) harsh sandy clay, columnar structure pH 6.0, gradual to
2ii	C	700+	weathered sandstone

Site Location:	3,093m	Sampling:	auger hole
Slope:	very gently inclined	Morph: type:	lower slope
Substrate:	clayey sandstone	Vegetation:	broom plain
Drainage:	impeded at top of B	PPF	Dy 5.42
Other Comments:	burnt 1966/67		

Layer	Horizon	(mm)	Description
0	01	surface	mat of *Melaleuca* sp. litter and lichen, although not as well developed as at PF7i
1i	A1	0 - 50	dark brown 7.5YR 3/3m organic sandy loam, earthy fabric, contains fine charcoal and a little fine quartz gravel, pH 5.5, clear and even to
1i	A12	50 - 200	brown 7.5YR 4/4m, 6/4d sandy loam, earthy fabric, charcoal and some fine quartz gravel, faunal channels, pH 5.5, clear and even to
1iib	A2cb	200 - 300	very moist bright brown 7.5YR 5/6m, 7/4d, very moist bleached clayey sand, some charcoal and fine quartz pebbles, pH 5.5, clear even to
2i	B2	300 - 500	yellowish brown 10YR 5/6 mottled dark reddish brown 5YR 3/6 more than 10%, very sandy clay, probably coarsely pedal, harsh, coarse quartz pebbles, pH 6.5, gradual to
2i	B3	500 - 1000	yellowish brown 10YR 5/6, mottles brownish gray (6/1), dark reddish brown (5YR 3/6), very sandy clay, harsh, pH7.0, gradual to
2ii	C	1000+	weathered sandstone

Site Location:	3,300m	Sampling:	auger hole
Slope:	very gently inclined	Morph: type:	lower slope
Substrate:	clayey sandstone	Vegetation:	broom plain
Drainage:	impeded at top of B	PPF	Dg 4.42

Other Comments: burnt 1966/67

Layer	Horizon	(mm)	Description
0	01	surface	litter from *Melaleuca* sp. lichen bound, sundews as at PF5i
1i	A1	0 - 50	brown (10YR 4/4m) sandy loam containing a little charcoal, earthy fabric, no gravel, organic. pH 6.5, clear and even to
1i	A12	50 - 200	brown (7.5YR 4/4m) clayey sand, very moist, charcoal, pH 6.5, gradual to
1i	A13	200 - 300	brown (7.5YR 4/6m) clayey sand as above but more moisture, clear and even to
1iib	A2cb	300 - 400	dull yellow orange (10YR 7/2m), with reddish brown (5YR 4/8) mottles, clayey sand, bleached layer, pH7.0, clear and even to
2i	B1	400 - 500	light reddish gray (2.5YR 7/1m) with dark reddish brown (2.5YR 3/6m) mottles, sandy clay, harsh, pH 7.0, gradual to
2i	B2	500 - 600	dark reddish brown (2.5YR 3/6m) with light reddish brown (2.5YR 7/1m) mottles, very sandy clay, harsh, pH 7.0, gradual to
2ii	C	600+	weathered sandstone

Site Location:	3,653m	Sampling:	auger hole
Slope:	very gently inclined	Morph: type:	upper slope
Substrate:	Pilliga Sandstone	Vegetation:	mallee
Drainage:	impeded at top of B	PPF	Db 4.42

Layer	Horizon	(mm)	Description
0	01	surface	litter of leaves and wood, top 5mm comes off in a layer. Many termite and ant workings
1i	A1	0 - 100	dull brown (7.5YR 5/4m) organic sandy loam, very bioturbated, earthy fabric, pH 6.5, clear and wavy to
1iia	A2cb	100 - 150	dull brown (7.5YR 6/3m, 7/1d) loamy sand, cement like, on top of and down cracks to form columns, quartz stones of varying sizes as layer within, bleached layer, pH 7.0, clear and wavy to
2i	B2	150 +	brown (7.5YR 4/6m) with mottles of A1 material, mainly as faunal channels, very harsh sandy clay, probably pedal (columnar structure), gradual to
2ii	C/R	??	Pilliga Sandstone (outcrops in road adjacent)

Site Location:	3,671m	Sampling:	auger hole
Slope:	very gently inclined	Morph: type:	upper slope
Substrate:	Pilliga Sandstone	Vegetation:	mallee
Drainage:	impeded at top of B	PPF	Db3.42

Other comments:part of line of auger holes across mallee/broom plain boundary (see also PF8iii, PF9ii-vi, PF12ii).

Layer	Horizon	(mm)	Description
0	01	surface	Surface covered with litter, single grained sands.
1i	A1	0 - 50	brownish black (7.5YR 3/2) highly bioturbated organic material, sandy loam. Earthy fabric, very porous with many faunal channels. Layer of fine quartz pebbles at 50mm on top of domes. Some ironstone throughout. pH 6.5. Wavy to
1iia	A2cb	50 - 150	light brownish gray (7.5YR 6/3m, 7/2d) paler dome top material - pinkish. Cemented but highly bioturbated with faunal channels through tops of domes. Domes 150 - 400 mm across. pH 7.0. Abrupt to
2i	B2	150 - 650	brown (7.5YR 4/4m) harsh sandy clay, very bioturbated. pH 7.0, gradual to
2ii	C/R	650+	dull brown (7.5YR 6/3) weathered sandstone, with brownish gray (7.5YR 6/1) clay bands.

PF8iii

Site Location:	3,696m	Sampling:	auger hole
Slope:	very gently inclined	Morph: type:	upper slope
Substrate:	Pilliga Sandstone	Vegetation:	mallee
Drainage:	impeded at top of B	PPF	Db3.42

Other Comments: see PF8ii

Layer	Horizon	(mm)	Description
0	01	surface	Surface cover of *Acacia* sp. and *E. viridis* litter mixed.
1i	A1	0 - 30	brownish black (7.5YR 3/2m) organic sady loam, earthy fabric. Quartz pebbles on top of domes, some ironstone throughout, bioturbated, pH6.5, wavy to
1iia	A2cb	30 - 100	light yellowish gray (7.5YR 6/3m, 7/2d) dome top material with quartz pebbles, domes 120 - 150mm across, pH 7.0, abrupt to
2i	B2	100 - 300	brown (7.5YR 4/4m) bioturbated harsh sandy clay, pH 7.0, gradual to
2ii	C/R	300+	dry, weathered sandstone.

PF8iv

Site Location:	3,580m	Sampling:	pit
Slope:	very gently inclined	Morph: type:	upper slope
Substrate:	Pilliga Sandstone	Vegetation:	mallee
Drainage:	impeded at top of B	PPF	Dy4.41

Layer	Horizon	(mm)	Description
0	01	surface	Surface of litter, bioturbation evident.
1i	A1	0 - 20	loamy sand, litter, many roots.
1i	A12	20 - 180	loamy sand, earthy fabric, many roots. Very bioturbated, many galleries and channels, fabric porous. Dull brown, 7.5YR 5/4m, 4/4d, quartz pebble layer (pebbles 0.5-1mm diameter) at base of layer. pH 5.5. Very wavy boundary between 180mm and 300mm describing columns.
1iia	A2cb	180 - 220	compact, cement-like layer, difficult to dig through. Tops of domes. Many large faunal channels penetrate through layer. Clayey sand, grayish brown 7.5YR 6/2d, small pebbles as above throughout layer. pH 6.5. Wavy to
2i	B2	220 - 750	sandy clay, columnar structure. Many roots, faunal channels filled with A1 material. Grayish brown 7.5YR 4/2m, pH 5.0. Gradual to
2i	B3	750 - 1000	sandy clay and weathered sandstone. Gradual to
2ii	C/R	1000 - 1500+	Weathered sandstone, light gray, 7.5YR 8/2 with brownish gray 7.5YR 6/1 sandy clay bands

Site Location:	3,803m	Sampling:	auger hole
Slope:	very gently inclined	Morph: type:	lower slope
Substrate:	alluvium	Vegetation:	broom plain
Drainage:	impeded at top of B	PPF	Dy 5.42

Other Comments: burnt 1966/67

Layer	Horizon	(mm)	Description
0	01	surface	*Melaleuca* sp. litter
1i	A1	0 - 50	dark brown 7.5YR 3/4m organic f s loam, pellety fabric (ant and termite casts) fine charcoal, roots, pH 5.5, clear to
1i	A12	50 - 200	brown 7.5YR 4/6m, sandy clay loam, earthy fabric, contains 2-5mm diameter qtz gravel, charcoal, pH 6.0, clear and wavy to
1iib	A2cb	200 - 300	yellowish brown 10YR 5/6m, 7/4d clayey wet sand, some red mottles, large diameter ironstone gravel, pH 6.0, clear and wavy to
3i	B1	300 - 400	bright brown 7.5YR 5/8m harsh sandy clay, some dark reddish brown mottles, 5YR 3/6m, ironstone gravel and some qtz pebbles, pH 7.0, gradual to
3i	B2	400 - 700	yellowish brown 10YR 5/8m harsh sandy clay with dull yellow orange 10YR 7/3m mottles, ironstone gravel, pH 7.0, gradual to
3i	B3	700 - 1000	bright yellowish brown 10YR 6/6m, with dull yellow orange 10YR 7/2m and dark reddish brown 5YR 3/6m mottles, pH 8.0, gradual to
3ii	C	1000+	alluvium

PF9ii

Site Location:	3,746m	Sampling:	auger hole
Slope:	very gently inclined	Morph: type:	lower slope
Substrate:	Pilliga Sandstone	Vegetation:	broom plain
Drainage:	impeded at top of B	PPF	Dy4.42

Other Comments: burnt 1966/67

Layer	Horizon	(mm)	Description
0	01	surface	Litter of *Acacia* sp. Evidence of ants and termites, single grained sand on surface.
1i	A1	0 - 100	dark brown (7.5YR 3/4m) sandy loam. Not as bioturbated as PF8iii. pH 6.0, clear to
1iib	A2cb	100 - 200	yellowish brown (10YR 5/3m, 7/2d) sandy loam. No sign of domes but material is similar to dome material. pH 7.0, clear to
2i	B2	200 - 700	yellow (10YR 5/8) harsh sandy clay. pH 7.0, gradual to
2ii	C/R	700 - 1000+	White mealy sandstone.

Site Location:	3,846m	Sampling:	auger hole
Slope:	very gently inclined	Morph: type:	lower slope
Substrate:	alluvium	Vegetation:	broom plain
Drainage:	impeded at top of B	PPF	Dy5.22

Other Comments: burnt 1966/67

Layer	Horizon	(mm)	Description
0	01	surface	Litter and single grained sand on surface.
1i	A1	0 - 100	Brownish black (7.5YR 3/2m) organic sandy loam, earthy fabric, highly bioturbated, contains charcoal. pH 6.0, clear to
1iid	A2	100 - 200	brown (10YR 4/4m) sandy loam, bioturbated, earthy fabric, charcoal, pH 6.5, clear to
3i	B2	200 - 600	yellowish brown (10YR 5/8m) harsh sandy clay, pH 6.5, gradual to
3i	B3	600 - 800+	yellow (10YR 5/8) sandy clay, with dark reddish brown mottles (5YR 3/6m) difficult to auger. pH 7.0.

Site Location:	3,871m	Sampling:	auger hole
Slope:	very gently inclined	Morph: type:	lower slope
Substrate:	sandstone	Vegetation:	mallee
Drainage:	impeded at top of B	PPF	Dy4.42

Other Comments: burnt 1966/67, in little raised mallee patch

Layer	Horizon	(mm)	Description
0	01	surface	Litter from mallee vegetation.
1i	A1	0 - 100	Dark brown (10YR 3/3m, 4/2d) very sandy loam, highly organic, some charcoal, bioturbated. pH6.5, clear and wavy to
1iia	A2cb	100 - 300	Dome material, grayish brown (7.5YR 5/2m, 7/3d), some quartz pebbles, highly bioturbated. Tongues of this material penetrate B2, pH 7.0, wavy and clear to
2i	B2	300+	yellowish brown (10YR 5/6m) sandy clay, very dry, unable to auger.

Site Location:	3,971m	Sampling:	auger hole
Slope:	very gently inclined	Morph. type:	lower slope
Substrate:	sandstone	Vegetation:	broom plain
Drainage:	impeded at top of B	PPF	Db4.22

Other Comments: burnt 1966/67

Layer	Horizon	(mm)	Description
0	01	surface	*Melaleuca* sp. litter on surface.
1i	A1	0 - 200	brown (7.5YR 4/4d, 3/2m) sandy loam, charcoal, earthy fabric, pH 5.5, clear to
1ii	A2	200 - 500	dull brown (7.5YR 5/3m, 6/2d) lighter coloured material, contains charcoal. sandy loam, earthy fabric, pH 6.5, clear to
2i	B2	500 - 600	mottled sandy clay, brown (10YR 4/4m with dark reddish brown 5YR 3/3 mottles), no charcoal, pH 6.5, gradual to
2ii	C/R	600 - 900+	mealy white sandstone?

PF9vi

Site Location:	4,021m	Sampling:	auger hole
Slope:	very gently inclined	Morph: type:	lower slope
Substrate:	alluvium	Vegetation:	broom plain
Drainage:	impeded at top of B	PPF	Db3.12

Other Comments: burnt 1966/67, broom cutters have disturbed site. Possible wind disturbance after cutting.

Layer	Horizon	(mm)	Description
0	01	surface	Very little litter on surface. Surface ridged with A1 material in piles.
1i	A1	0 - 200	brown (7.5YR 4/4d, 3/2m) sandy loam, bioturbated, contains charcoal, earthy fabric, very few roots, pH 5.5, clear to
3i	B2	200 - 400	sandy clay, brown (10YR 4/4m), pH 6.5, gradual to
3ii	C/R	400+	mottled sandy clay - alluvium?

Site Location:	4,469m	Sampling:	pit
Slope:	level	Morph: type:	flat
Substrate:	alluvium	Vegetation:	sand monkey open-woodland
Drainage:	free	PPF	Uc 5.11

Layer	Horizon	(mm)	Description
0	01	surface	layer of litter, mainly from *Callitris* sp.
1i	A1	0 - 50	thin layer of coarse sand, single grain, over a thin crust which breaks up easily, vesicular underneath in some areas, in others a more clay crust bound with lichen which forms pillars on erosion, over brown 7.5YR 4/6m, 6/6d coarse sand containing a little organic material, pH 6.0, even clear to
3i	B2	50 - 1000	bright brown 7.5YR 5/8m coarse sand, some faunal channels back filled with A1 material, sandy fabric, charcoal, pH 5.0, gradual to
3ii	B/C	1000+	bright brown 7.5YR 5/8m slightly finer sand, contains some clay, more coherent and compacted, contains charcoal, pH 6.0 Continues

Site Location:	6,702m	Sampling:	auger
Slope:	very gently inclined	Morph: type:	lower slope
Substrate:	alluvium	Vegetation:	tall closed-forest
Drainage:	gilgai area	PPF	Ug6.1

Layer	Horizon	(mm)	Description
0	01	surface	10mm deep *Casuarina* sp. litter, becomes finer with depth,
1i	A1	0 - 20	brownish black (10YR 3/2m, 5/4d) fine sandy clay loam, porous, fine pedal fabric, 5mm quartz pebbles throughout, fine roots, pH 6.5, clear to
1i	A11	20 - 200	black (10YR 2/1m, 2/2d) fine sandy light clay, highly pedal, porous polyhedral 5mm peds, many roots, bioturbated, pH 7.0, clear to
3i	B2	200 - 400	brownish black (5YR 2/2m, 3/2d) fine sandy light clay, similar pedality to above, pH7.0, clear to
3ii	C	400 - 1000+	dull yellow brown (10YR 5/3m) fine sandy light clay, pedality as above, little ironstone gravel, pH 7.0.

Site Location:	4,103m	Sampling:	pit
Slope:	very gently inclined	Morph: type:	lower slope
Substrate:	alluvium	Vegetation:	mid-height woodland
Drainage:	impeded at top of B	PPF	Uc 4.32

Layer	Horizon	(mm)	Description
0	01	surface	litter from *E. crebra* etc. Surface layer of whole leaves, twigs, branches, large faecal pellets, under is layer of 20mm diameter charcoal pieces, then to comminuted litter/soil combined. Some lichens and mosses
1i	A1	0 - 100	dark brown 10YR 3/3m, 5/2d organic loamy sand, bioturbated, charcoal, some fine to coarse quartz gravel, earthy fabric, pH 5.5, clear even to
1iid	A2	100 - 300	yellowish brown 10YR 5/6m, 6/4d very moist sand, quartz gravel (some to 2mm diameter), contains fine charcoal. Moisture seeps in at this level, pH 6.0, clear, even to
3i	B2	300+	dull yellowish brown 10YR 4/3m hard, compacted coarse clayey sand, massive, harsh. Some orange mottles. pH 7.0 Continues

PF12ii

Site Location:	4,101m	Sampling:	auger hole
Slope:	very gently inclined	Morph. type:	lower slope
Substrate:	alluvium	Vegetation:	mid-height open-woodland
Drainage:	impeded at top of B	PPF	Dy4.12

Layer	Horizon	(mm)	Description
0	01	surface	Surface covered with coarser single grained sand and litter.
1i	A1	0 - 200	brownish black 10YR 3/2m, 5/3d, organic sandy loam with charcoal throughout. Earthy fabric, pH 5.5, becomes less organic with depth, clear to
1i	A12	200 - 300	yellowish brown 10YR 5/6m, 6/3d sandy loam, contains charcoal, earthy fabric, pH6.0, clear to
3i	B2	300 - 500	dull yellowish brown 10YR 5/3 very coarse sandy clay. Quartz pebbles and ironstone. less bioturbated. pH6.5, gradual to
3ii	C	500+	sandy clay.

PF12iii

Site Location:	4,115m	Sampling:	pit
Slope:	very gently inclined	Morph. type:	lower slope
Substrate:	alluvium	Vegetation:	open-woodland
Drainage:	impeded at top of B	PPF	Dy4.41

Layer	Horizon	(mm)	Description
0	01	surface	litter from *E. crebra* etc. Surface layer comprises whole leaves, twigs, branches, large mammal faecal pellets. Patches of single grain sand. Under is a layer of part leaves and 10 - 20mm diameter charcoal pieces, then to comminuted litter/soil combined, many faunal burrows.
1i	A1	0 - 50	brownish black 10YR 2/3m, 5/3d, organic coarse loamy sand, highly porous, earthy fabric. Many faunal (termite) channels, roots matting layer together, qtz pebbles 0.5mm diam. pH 5.0, grad to
1i	A12	50 - 500	brown 10YR 4/4m, 6/4d loamy sand, contains a little clay. Earthy fabric, becomes denser with depth, fewer faunal burrows than above, quartz pebbles 0.5mm, pH 3.5, abrupt wavy to
1iib	A2cb	500 - 700	dull brown 7.5YR 6/3m, 8/1d bleached layer, coarse loamy sand, many large (1mm) quartz pebbles, very porous, cemented earthy fabric, some faunal channels, pH 3.5, sharp and wavy to
3i	B2	700+	dull yellow brown 10YR 5/4 massive coarse sandy clay, very hard, pH 4.5 continuing.

PF13i

Site Location:	5,458m	Sampling:	pit
Slope:	level	Morph. type:	flat adj to creek
Substrate:	alluvium	Vegetation:	mid-height opem-woodland
Drainage:	impeded at top of B	PPF	Uc 4.21

Layer	Horizon	(mm)	Description
0	01	surface	surface coverd with litter.
1i	A1	0 - 50	brownish black 10YR 3/2m, 5/2d organic coarse sandy loam, bioturbated, pellety appearance, charcoal. pH 5.5. Gradual to
1i	A12	50 - 300	dark brown 10YR 3/4m 5/4d coarse loamy sand, less bioturbated and organic, more clay. Very fine charcoal. pH 6.0. Gradual to
1iid	A2	300 - 450	brown 10YR 4/4m, 6/4d very moist, loamy sand favoured by kurrajong roots. pH 6.0. Gradual to
3i	B2	450 - 800	yellowish brown 10YR 5/6m coarse loamy sand, yellow and brown rounded pebbles. pH 6.5. Abrupt to
3ii	D	800+	concreted sand, open textured. pH 7.0.

ECOLOGY RESERVE PROFILES

Location:	Grid Ref. 256617 on the U0960-7 Pymble Orthophotomap. See Figure 8.1 for details.
Climate:	Average annual rainfall 1211 mm, summer maximum.
Vegetation:	Dry sclerophyll Woodland
Substrate:	Hawkesbury sandstone
Drainage:	Free
Land Use:	Reserve.

Profile descriptions are given with both layer and standard terminology. The soil stratigraphy at the site is as follows:

Layer 1: sandy mobile layer, divided into Layer 1i (organic topsoil), 1iia (bleached A2), 1iib (sporadically bleached A2) and 1iic (unbleached A2).

Layer 2: divided into Layer 2i (sandstone weathered *in situ* to a clayey subsoil) and Layer 2ii (weathered sandstone).

Layer 3: divided into Layer 3i (alluvium weathered *in situ* to a clayey subsoil) and Layer 3ii (weathered alluvium).

Sampling: pit — Slope: medium

Morph. type: upper slope — PPF Dy 4.51

Layer	Horizon	(mm)	Description
0	O1	surface	Armoured with ironstone clasts, platey and some large (to 100x200mm). Single grain white sand between and under clasts, many burrow entrances beneath stones. Some litter, no visible charcoal. Algal mat below single grained sand layer. Bioturbation in form of ant funnels.
1i	A1	0 - 20	sandy loam, organic, roots and litter matted together with fungal hyphea. Some very fine charcoal, small ironstone pebbles 10mm diameter. 10YR 2/3m, 4/3d. pH 6.0. Sharp and even to
1iic	A2	20 - 50	sandy loam, roots, little visible charcoal, organic material. Rounded ironstone pebbles 10mm diameter, earthy fabric, 10YR 3/4m, 5/3d, patches of 6/2d. pH 6.0. Clear and wavy to
2i	B1	50 - 100	coarse sandy clay loam, many subangular ironstone pebbles < 50mm diameter. Some fragments of sandstone. 10YR 4/3m, 5/4d. Clear to
2i	B2	100 - 300	sandy clay, weathered sandstone throughout, coarsely pedal, porous. 10YR 5/6m. 6/4d with mottles (<10%) 5YR 4/6 with depth, pH 5.5, gradual to
2ii	C	300+	Weathered sandstone.

Site Location:	on fire trail	Sampling:	edge of cutting and auger hole
Slope:	medium		
Morph. type:	mid slope	PPF	Dy 4.71

Layer	Horizon	(mm)	Description
0	01	surface	Sparse litter over fine, decomposed litter and fine charcoal over algal mat. Ant funnels. Few platey ironstone clasts (to 100x 200mm). Patches of single grain white sand between and under clasts, many burrow entrances beneath stones.
1i	A1	0 - 20	sandy loam, organic, matted together with roots and decomposed litter with fungal hyphea. Some very fine charcoal, small ironstone pebbles 10mm diameter. Earthy fabric. 10YR 5/8d, 3/1m. pH 6.0. Sharp and even to
1iib	A2	20 - 300	sandy loam, roots, a little visible charcoal. Very little organic material. Earthy fabric. 10YR 4/4m, 6/3d, patches of 7/3d. Sporadic bleach. pH 6.0. Flat sst to 20x60mm stone layer at base A_2. Clear and wavy to
2i	B	300 - 700	sandy clay, mod pedal, subangular blocky rough peds, >50mm diameter, v porous. Whole coloured to 500mm 10YR 5/6m; mottles of 10YR 4/4, 7.5YR 5/6 increasing with depth. pH 5.5. Gradual to
2ii	C	700+	decomposed sandstone.

ER3

Sampling: auger hole Slope: level

Morph. type: flat adjacent to creek Substrate: alluvium

PPF Uc 5.11

Layer	Horizon	(mm)	Description
0	01	surface	Thick litter over layer charcoal up to 20mm diameter, ironstone pebbles up to 10mm diameter and much blue metal from roads. Single grain coarse sand between and under stones.
1i	A1	0 - 100	very coarse single grain sand mixed with blue metal and large flat ironstone clasts. Much coarse charcoal plus finer (1-2mm) size charcoal. Some roots binding material but little organic material. Sandy fabric. Little bioturbation. 10YR 4/4m, 6/2d. pH 8.0. Gradual to
3i	B1	100 - 200	as above with fewer ironstone and blue metal clasts and less charcoal. Sand less coarse, sandy fabric with a little clay staining hands. 10YR 3/2m, 4/3d. pH 8.0. Gradual to
3i	B2	200 - 400	clayey coarse sand, as above with fewer stones. 10YR 3/2m, 4/3d. pH 7.5. Gradual to
3i	B3	400 - 600	clayey coarse sand, as above, 10YR 3/3m, 4/4d. pH 6.0. Gradual to
3ii	C	600 -1000+	continuing as above, pH 5.5

OXFORD FALLS PROFILES

Location:	Grid Ref. 337267 on the Hornsby 1:25000 Orthophotomap Sheet. See Fig. 3.1 for details.
Climate:	Average annual rainfall 1211 mm, summer maximum.
Vegetation:	Dry sclerophyll Woodland
Land Use:	Recreational Reserve.

Profile descriptions are given with both layer and standard terminology. The soil stratigraphy at the site is as follows:

Layer 1: sandy mobile layer, divided into Layer 1i (organic topsoil), 1iia (bleached A2) and 1iib (pans).

Layer 2: divided into Layer 2i (sandstone weathered *in situ* to a clayey subsoil) and Layer 2ii (weathered sandstone).

The Layers in the cores are numbered from the surface.

OF1

Sampling:	soil pit	Slope:	v gently inclined
Morph. type:	flat	Substrate:	sandstone
Drainage:	medium	Vegetation	shrubs
PPF	Uc 2.36		

Layer	Horizon	(mm)	Description
0	01	surface	Surface of thicker litter under which is layer of white single grained sand
1i	A1	0 - 40	Brownish gray 10YR 4/2(d) 4/1(m) organic sand, sandy fabric. Contains charcoal, small quartz pebbles. Matted together with roots which decrease with depth, pH 4.5, clear and even to
1iia	A2cb	40 - 140	Light gray 10YR 8/1(d) sand, conspicuously bleached layer, few roots, some fine charcoal, sandy fabric, pH 5.0, clear and convoluted to
1iib	Rhs	140 - 180	Brownish black 10YR 3/2 organic pan above a yellowish brown 10YR 5/6 iron pan within the sandstone.
2ii	R	180+	sandstone

Sampling:	soil pit	Slope:	v gently inclined
Morph. type:	flat	Substrate:	sandstone
Drainage:	medium	Vegetation:	shrubs
PPF	Uc 2.36		

Layer	Horizon	(mm)	Description
0	01	surface	Litter under which is layer of white single grained sand
1i	A1	0 - 50	Dull yellowish brown 10YR 4/3(d) 4/1(m) organic sand, sandy fabric. Contains charcoal, small quartz pebbles. Matted together with roots which decrease with depth, pH 5.0, clear and even to
1iia	A2cb	50 - 300	Dull yellowish orange 10YR 7/2(d) sand, conspicuously bleached layer, few roots, some fine charcoal, sandy fabric, pH 5.0, clear and convoluted to
1iib	Rhs	300 - 400	Brownish black 10YR 3/2 organic pan above a yellowish brown 10YR 5/6 iron pan within the sandstone.
2ii	R	400+	sandstone

OFC1

Sampling:	small core (155mm)	Slope:	level
Morph. type:	flat	Substrate:	clay (kaoline)
Drainage:	impeded	Vegetation:	*Gahnia* swamp
PPF	0		

Layer	(mm)	Description
0	surface	Thick mat of swamp vegetation and decaying litter, spongy and waterlogged.
1	0 - 50	Matted vegetation with a little sand. Peat. Waterlogged and smelling of hydrogen sulphide. Thick root mat binds material together. Little charcoal and some quartz pebbles 2mm diameter. Abrupt to:
2	50 - 55	Light gray 10YR 8/1 coarse sand, contains a little fine charcoal. Very little organic material. pH 8.0, abrupt to
3	55 - 65	Charcoal layer, contains a little quartz sand.
4	65 - 120	Dull yellowish brown 10YR 5/4(d) 3/3(m) coarse sandy loam. Contains much decomposing vegetation and roots, quartz pebbles and charcoal. pH 7.5, abrupt to:
5	120-155	Dark brown 10YR 3/3(d) 2/1(m) organic sandy loam. Organic layer, some quartz pebbles and charcoal.
	155+	Continues.

OFC2

Sampling:	155mm core	Slope:	level
Morph. type:	flat	Substrate:	clay (kaoline)
Drainage:	impeded	Vegetation:	*Gahnia* swamp
PPF	0		

Layer	(mm)	Description
0	surface	Thick mat of swamp vegetation and decaying litter, spongy and waterlogged.
1	0 - 100	Matted vegetation with a little coarse sand, mainly peat. Waterlogged and smelling of hydrogen sulphide with a root mat binding material together. Little charcoal and some quartz pebbles 2mm diameter. Abrupt to:
2	100-105	Light gray 2.5YR 8/2 coarse sand, contains a little fine charcoal. Very little organic material. pH 8.0, abrupt to
3	105-110	Charcoal layer, contains a little quartz sand and quartz pebbles.
4	110-155+	Yellowish brown 2.5YR 5/4(d) 3/3(m) coarse sandy loam. Contains much decomposing vegetation and roots, quartz pebbles and charcoal. pH 7.5, Continues.

APPENDIX C

VEGETATION SITES

Vegetation sites were located during a field trip on October 16-23, 1986.

Location

Topographic Map: Cubbo, 8736-N first edition 1;50 000 series. AMG reference is in zone 55, sites located along Dunwerian Rd, from Junction Rd (711500mE 6605800mN) to Pine Rd (708000mE 6610400mN), numbered from East to West, with distances measured from Junction Rd.

Descriptions

Descriptions are after Walker and Hopkins, 1984. Dominant species in each stratum at each site are recorded. Nomenclature follows the National Herbarium, Royal Botanic Gardens, Sydney. Common names follow Cunningham *et al.* (1981). Identifications were made by E. Norris.

Site 1: creek

350m

Slope:	level
Morphological type:	flat adjacent to creek
Substrate material:	alluvium
Vegetation structure:	tall open-forest

Dominant species:

Trees:	*Eucalyptus crebra*	Narrow-leafed ironbark
Shrubs:	*Dodonaea viscosa* ssp. *cuneata*	Broad-leaf hopbush
	Melaleuca uncinata	Broombush
Herbs:	*Bulbine semibarbata*	
Grasses:	*Stipa setacea*	Corkscrew grass
	Aristida benthamii	Betham's wiregrass
Ferns:	*Cheilanthes austrotenuifolia*	

Site 2: broom plain, burnt 51

700m

Slope:	gently inclined
Morphological type:	hillslope
Substrate material:	Pilliga sandstone
Vegetation structure:	shrubland

Dominant species

Tall Shrubs:	*Melaleuca uncinata*	Broombush
	Acacia tindaleae	Golden-top wattle
Shrubs:	*Calytrix tetragona*	Common heath or fringe myrtle
	Eriostemon difformis ssp. *difformis*	Small-leaf wax flower

Herbs:	*Dampiera lanceolata*	Grooved Dampiera
	Cassytha melantha	Mallee strangle-vine

Site 3: ridge

1,100m

Slope: upper slope, very gently inclined

Morphological type: ridge

Substrate material: iron-rich sandstone, possibly with conglomerate

Vegetation structure: tall open-forest

Dominant species:

Trees:	*Eucalyptus crebra*	Narrow-leafed ironbark
	Acacia neriifolia	Oleander wattle
Shrubs:	*Prostanthera ringens*	
	Phebalium squamulosum ssp. *gracile*	
Herbs:	*Stipa scabra* ssp. *scabra*	Rough speargrass
	Thyridolepis mitchelliana	Mulga grass
	Calotis cuneifolia	Purple Burr-Daisy

Site 4: midslope

1,400m

Slope: very gently inclined

Morphological type: mid slope

Substrate material: sandstone

Vegetation structure: tall open-forest

Dominant species:

Trees:	*Eucalyptus crebra*	Narrow-leafed ironbark
	Acacia neriifolia	Oleander wattle

Tall Shrubs:	*Melaleuca uncinata*	Broombush
Shrubs:	*Hibbertia* sp.	Guinea-flower
Grasses	*Stipa setacea*	Corkscrew grass
Ferns:	*Cheilanthes austrotenuifolia*	

Site 5: broom plain, burnt 66/67

2,100m

Slope:	very gently inclined
Morphological type:	lower slope
Substrate material:	sandstone (clayey?)
Vegetation structure:	shrubland

Dominant species:

Tall Shrubs:	*Melaleuca uncinata*	Broombush
	Calytrix tetragona	Common heath or fringe myrtle
	Micromyrtus sessilis	Fringed heath-myrtle
Herbs:	*Angianthus pusillus*	Dwarf cup-flower
	Gnephosis tenuissima	
	Chrysacoryne pusilla	
	Dianella revoluta	Spreading flax-lily

Site 6: broom plain burnt 66/67

3,093m

Slope:	very gently inclined
Morphological type:	lower slope
Substrate material:	sandstone (clayey?)
Vegetation structure:	closed shrubland

Dominant species:

Tall Shrubs:	*Melaleuca uncinata*	Broombush
	Acacia tindaleae	Golden-top wattle
Shrubs:	*Melaleuca densispicata*	
	Hibbertia sp.	Guinea-flower

Site 7: same broom plain as site 6 but area burnt 51

3,300m

Slope: very gently inclined

Morphological type: lower slope

Substrate material: sandstone, clayey?

Vegetation structure: shrubland

Dominant species:

Tall Shrubs:	*Melaleuca uncinata*	Broombush
	Acacia triptera	Spur-wing wattle
Shrubs:	*Calytrix tetragona*	Common heath or fringe myrtle

Site 8: mallee site

3653m

Slope: very gently inclined

Morphological type: upper slope

Substrate: iron-rich sandstone

Vegetation structure: open-woodland

Dominant species:

Trees:	*Eucalyptus viridis*	Green mallee

Shrubs:	*Dodonaea viscosa* ssp. *cuneata*	Hopbush
Grasses:	*Stipa setacea*	Corkscrew grass

Site 9: broom plain, burnt 66/67

3803m

Slope: very gently inclined

Morphological type: lower slope

Substrate: sandstone?

Vegetation structure: shrubland

Dominant species:

Tall Shrubs:	*Melaleuca uncinata*	Broombush
	Acacia tindaleae	Golden-top wattle
Shrubs:	*Calytrix tetragona*	Common heath or fringe myrtle
	Micromyrtus sessilis	
	Baekea densifolia	

Site 10: sand monkey

4469m

Slope: level

Morphological type: flat

Substrate: alluvium

Vegetation structure: open-woodland

Dominant species:

Trees:	*Callitris glaucophylla*	
	Eucalyptus chloroclada	Baradine gum

Shrubs	*Allocasuarina diminuta* ssp. *diminuta*	
	Brachylome daphnoides	
	Xanthorrhoea glauca ssp. *angushfolia*	
Grasses	*Aristida benthamii*	Betham's wiregrass

Site 11: Gilgai

6,702m (Pine Road)

Slope: level

Morphological type: flat

Substrate: clay

Vegetation structure: tall closed-forest

Dominant species:

Trees:	*Casuarina cristata*	Belah
	Eremophila mitchellii	Budda
	Mixed herbaceous understory	

Site 12: Forest

4,103m [82m west of first big Ironbark after Broom Plain (Site 9)]

Slope: very gently inclined

Morphological type: lower slope

Substrate: alluvium

Vegetation structure: mid-height open-woodland

Dominant species:

Trees:	*Allocasuarina leuhmannii*	Bull oak
	Eucalyptus crebra	Narrow-leafed ironbark

Shrubs:	*Callitris glaucophylla*	
	Acacia tindaleae	Golden-top wattle
Grasses:	*Stipa scabra* ssp. *scabra*	Rough speargrass
	Aristida ramosa var. *ramosa*	Wiregrass

Site 13: bank of creek

5,458m

Slope: level

Morphological type: flat adjacent to creek

Substrate material: alluvium

Vegetation structure: mid-height open-woodland

Dominant species:

Trees:	*Allocasuarina leuhmanii*	Bull oak
	Eucalyptus crebra	Narrow-leaved ironbark
Shrubs:	*Callitris glaucophylla*	
	Acacia tindaleae	Golden-top wattle
Grasses:	*Stipa scabra* ssp. *scabra*	Rough speargrass
	Aristida ramosa var. *ramosa*	Wiregrass

Site 14: Box

5,800m (Pine Road)

Slope: very gently inclined

Morphological type: midslope

Substrate material: alluvium

Vegetation structure: tall woodland

Dominant species:

Trees:	*Eucalyptus pilligaensis*	Pilliga grey box
	Callitris glaucophylla	
Shrubs	*Dodonaea viscosa* ssp. *cuneata*	Broad-leaf hopbush

APPENDIX D

D1: TECHNIQUES FOR STUDYING LITTER DECOMPOSITION

Introduction

Appendix D1 examines the literature relevant to the mesh bag litter study undertaken and described in Chapter 8.

Techniques for studying litter decomposition

The various techniques which have been used to examine the rates of decomposition of litter were discussed by Woods and Raison (1982), with particular reference to the Australian eucalypt forests. They pointed out that Australian forests often occupied sites of low nutrient status thus the rate of mineralization of the litter affects the long term productivity of the forest. The rapid accumulation of combustible litter in these forests is an important consideration in forest management.

The eucalypt forest differs markedly from the northern hemisphere forest. Trees are evergreen and shed litter continuously with a seasonal periodicity. Concentrations of N and P in the leafy component of the litter fall is often very low, less than other world forests, and the litter may contain a high proportion of wood, thus studies which examine leaf decomposition alone and especially those which examine green picked leaves may give an incomplete picture. Several years of measurement are required due to the variable climate; the large annual variation in rainfall for example. Studies which are based on 1 years observation are difficult to interpret (Webb, Tracey, Williams and Lance, 1969). The fire history of an area often interupts cycles of decomposition, preventing the attainment of steady state accumulations.

Sampling

Woods and Raison (1982) make several recommendations for consideration when selecting a sample. Freshly picked green leaves should not be used since these have a chemical composition which is different from abscissed leaves and are also more rapidly consumed by invertebrates. Due to these factors, weight loss over the first year in particular may be overestimated. The addition of fresh litter over the top of a sample also adds nutrients. They also point out that the loss of leaf area is different from the loss of nutrients per unit area.

Examination of specific techniques

Techniques fall into two categories; the measurement and observation of changes in a sample (mesh bags, tethered leaves) and measurement and observation of undisturbed litter beds, the collection of leaf leachate and the calculation of a decomposition constant (k). Woods and Raison (1982) conclude that decomposition rates are difficult to monitor directly in the field and that two independent methods should be used simultaneously.

1. Mesh litter bags:

There are three techniques available for the use of mesh bags (Suffling and Smith, 1974). A large number of bags of known weight can be placed in the field at the beginning of the experiment and a randomly chosen sample removed and weighed at the end of each time period; a set of bags can be put out at the beginning of each time period then removed at the end when another set is put out; or the bags can be removed, weighed and replaced.

Suffling and Smith examined the losses due to spillage, and concluded that the use of medium mesh sizes and the placing of the bags in paper bags during transportation is advisable. Any spillage may then be dried and weighed. Repeated drying is believed to increase decomposition rates, but this they found to be negligible.

Woods and Raison (1982) state that the use of bags is the most simple and widely used method. They suggest the bags should be sequentially removed from the field and not disturbed and replaced. The use of only one species of litter or of leaf material only, causes results to be not representative. Moisture status is higher in confined bags. The inhibition of activity of invertebrates may lead to an under-estimation of rates of decay.

MacLean and Wein (1978) examined changes in the weight and nutrient content of litter over time using mesh bags which they removed three at a time. They also examined the decomposition rates for wood of each species by tying weighed branches to lines and removing them sequentially from the field. O'Connell (1987) gathered a bulk sample of Karri leaf litter in suspended bags in a forest in South West Australia 250 km south of Perth. Approximately 20 g of leaf litter was placed in 3 mm mesh 25 x 25 cm terylene bags. Collected bags were dried at 70°C, brushed free of soil and weighed.

2. Tethered leaves:

This method is very suitable for forests with a sparse or discontinuous litter layer where litter bags would give an unrealistic pattern.

3. Artificial substrates:

This technique involves, for example, the loss of strength in cotton strips. Difficulty is experienced in interpreting these studies since calibration is required.

4. Litter leachate collection:

A collector is placed between the litter pack and the mineral soil. Care must be taken that runoff cannot enter.

5. The calculation of decomposition constants (k).

This method examines the relationship between the annual litter fall (L) and accumulated litter (X). When X is stable, $L = kX$. The rate of decomposition is not constant throughout the life of the litter.

The weight of the litter varies seasonally, spatially and annually, and it is difficult to separate soil from samples. k does not provide an accurate picture of the actual pattern of weight loss; longer time periods are required.

The mass balance model (Jenny, Gessel and Bingham, 1949; Olson 1963) assumes that the litter pool is in steady state; however where the forest is regularly disturbed by fire, this is not necessarily the case. Birk and Simpson (1980) quote figures for fire frequency; grassland 5 years, dry eucalypt forests 11 years and wet eucalypt forests 40 - 50 years. The introduction of controlled burning means that it is unlikely that the floor of a eucalypt forest ever attains steady state. A decay constant calculated assuming steady state would thus considerably overestimate the forest floor turnover rate. Birk and Simpson calculated the possible magnitude of this overestimation and found it decreased rapidly the first few years after a fire.

The model also assumes continuous litter fall throughout the year, and that it is constant year to year. Litter fall in eucalypt forests is strongly seasonal and varies year to year. The model also assumes that a constant proportion (k) of the forest floor turns over rapidly, and Birk and Simpson point out that there is little evidence of this. Lower layers in the litter profile decompose more slowly and fire may remove a considerable proportion of the total litter which falls between fires.

6. Balance sheet approach

Litter disappearance = initial amount + litter production - final amount. In periods of less than 1 year this may give poor results due to the high degree of spatial variability in eucalypt forests.

7. Ageing of *in situ* litter:

This involves a stratigraphic approach; differentiating between litter of differing ages by physical appearance and position in the litter pack.

8. Respiration of litter and surface soil:

This method is not widely used, mainly due to problems with moisture fluctuations and difficulty in estimating the live root contribution.

The loss of elements from decomposing litter

Attiwell (1968) studied the loss of dry matter and some elements during the decomposition of *Eucalyptus obliqua* in Victoria. Two methods were used; selected quantities of litter were placed in boxes of fine wire mesh and one box analysed for components every 3 months for 2 years, and the annual decomposition constant was calculated, by estimating weight and elemental composition from 12 randomly chosen quadrats. The order of mobility of elements was Na, K, Ca, Mg, P. The cycling of P was compared with Russian hardwood data. The eucalyptus litter study showed that P was held in the F and H layers, and that 70% of the P was withdrawn before litter fall (also reported by Ashton, 1975). In the Russian case, the full amount of P is returned annually in leaf litter, while in the eucalypt very little is to be found in the litter.

Ashton (1975) analysed litter from an *E. regnans* forest in Victoria for N, P, Ca and K. The total weight of nutrients returned by *E. regnans* was found to be similar to several American conifers, and the weight of nutrient return in this wet sclerophyll forest was similar to others similar reported, but 2-6 times greater than that of dry sclerophyll forests.

Rates of destruction of litter were measured by Ashton (1975) directly by the use of litter in baskets, and indirectly by using the ratio of the weight on the forest floor to the annual litter fall. It was found that young forests (litter half lives of 3.32y and 3.10y) decayed more slowly than mature forests (2.54y and 2.82y) [collection over 2 and 4 years].

Birk (1979) conjectured that the understory vegetation may have an important effect on rate and return of nutrients to the soil (see Springett (1978) on two-pathway nutrient cycling system).

The main environmental factor to consider in litter decomposition is temperature, with moisture and aeration also being very important along with pH and base content. The base content of litter varies throughout the year. Remezov (1961, in Williams and Gray 1974:622) examined the effect of leaching on *Quercus* litter and found the percentage of elements remaining after two months to be:

element	K	P	N	Mg	Ca	Si	Al	Fe
%	46	53	65	65	72	83	90	100

The measurement of these elements is complicated by the addition by precipitation from the canopy.

Lamb (1985) measured the nutrient content of the litter mass and fresh-cut and fresh-fallen litter. Nitrogen, phosphorous, potassium and sodium were probably withdrawn from the leaves prior to abscission or (particularly in the case of Na) lost by rapid leaching. Nutrient loss strongly corelated with weight loss but Lamb pointed out that mesh bags may become contaminated with soil and debris, or damaged by animals.

Conclusions

Appendix D1 looked at the methods which have been used to measure litter decay rates. The problems involved in each method were evaluated, and it was decided to use the mesh bag method in the Pilliga litter study (Chapter 8).

The main reasons for this decision were:

1. The method is straightforward, provided the problems discussed by various authors are taken into account.
2. The method had been used in the Sydney area by Lamb (1985) in an area near the Oxford Falls site; thus comparisons could be drawn between the two studies.

D2: The Effects of Fire on litter

Introduction

In the Australian environment there is evidence that fires have occurred throughout the Tertiary and Quaternary (Kemp, 1978) although timing and frequency may have varied considerably.

Low intensity ground fires or high intensity wildfires comprising severe surface fire and crownfire occur. Wildfires occur often during dry months and may destroy vegetation as well as all ground litter and humus. Changes to the soil include increased exposure of surface soil and the release of nutrients. Fire is very important in the Australian environment, and its effects on plant opal were discussed in Chapter 6. This Appendix examines some of the background literature.

Temperature

Forest fires lead to a major change in the temperature of litter, although this change is less marked in surface soil. Roberts (1965) reports the following temperatures in a sandy loam during the burning of windrows: 500°C at 2.5 cm, 350°C at 5 cm and 200°C at 10 cm. Under a grass burn temperatures recorded in clay soil were: surface 300°C, with a rise of 27 - 36°C at 2 cm depth over three minutes then a drop at the rate of 0.3°C per minute with negligible temperature change at 4 cm (Scotter, 1970). Floyd (1966): looked at 3 fuel types:

(a) dry leaves and branchlets; surface 510°C, over 100°C for 15 minutes, at 2.5 cm 44°C;

(b) branches 10-20 cm diameter stacked to 2 m height; surface 386°C, over 100°C for 2 hours, maximum temperatures at 2.5, 5.0, 10 cm depths were 85, 67 and 48°C respectively;

(c) windrow, logs over 1 m diameter; temperature trends similar to branches 10-20 cm in diameter.

From this information it would seem very unlikely that there would be changes to, for example, plant opal within the soil, since the high temperatures are not attained for a sufficient length of time.

Raison *et al.* (1986) measured the temperatures at the soil surface and at several depths during and at intervals up to 33 months after a low intensity prescribed burn in a sub-alpine *E. pauciflora* forest. They found steep temperature gradients were generated during the fire and mean daily maximum temperature was higher on burnt plots after the fire.

Effects on soil properties

Clinnick (1984) in a review of the literature on the effect of fire on soil structure noted that it would be expected that sandy soils would have an overall deterioration in structure while heavier soils may be improved. The effect on porosity is often unpredictable. Clinnick quoted Pillsbury (1953) and Beaton (1959) who demonstrated no reduction in the number of large pores following fire while Australian research shows an increase (Craig, 1968; in Clinnick, 1984).

Effect on water content varies. Intense heat may change the water holding capacity of some soils (see Clinnick and Willatt, 1981). Hydrophobic organic compounds from plants may produce water repelant layers. On the other hand, infiltration capacity in finely textured soils may be improved.

Chemical effects include a change in pH, although around Sydney it has been reported that there is no change in pH possibly because of the low organic matter content of the soils (Beadle, 1940). Clinnick (1984) noted that a fire may completely burn the organic horizon and result in a loss of all the N and almost all of the S present, although N in the soil may be increased. In a cool burn (less than 200°C) the amount of available P may not increase greatly while in a hot burn (over 400°C) much may be released. Grove, O'Connell and Dimmock, (1986) note that after an intense fire in a jarrah forest a high proportion of the nutrients in the litter layer were mineralized.

Khanna and Raison (1986) found that in the surface soil under a *E. pauciflora* forest near Canberra, changes in soil solution chemistry would increase nutrient availability to the vegetation during the first year after burning. Cheney, Raison and Khana, (1980) note that more than a million hectares of Australian Eucalypt forests are burnt annually. The concentration of various elements in ash varies by an order of magnitude, and a significant proportion may be transfered to the atmospher in gas or particulate form (Khanna and Raison, 1986). Solublisation of the elements is usually of the order Na, K, Mg, Ca, P. Khanna and Raison also report a high concentration of silica in particularly the fine gray ash.

Biological effects

Fire will affect factors which influence organisms; pH, moisture, temperature, food supply and soil structure.

1. Microorganisms: The effect depends on the temperature reached. Initially numbers will be reduced but increased pH in the ash is found to lead to higher levels.

2. Soil fauna: Springett (1976) found a reduction of 50% in populations of microarthropods after a hot burn, and which might be attributed to the effects of decrease in moisture content rather than heat. In a mild fire species diversity and density were reduced after burning and did not recover to their pre-burning values during the normal fire rotation of 5 - 7 years, thus leading to a simplification of the litter fauna and flora. Others have found that the effect of fire on litter fauna are not as great. Beadle (1940) experimented with the effects of varieties of fire on organisms at various depths and found that with natural fires soil fauna to a depth of 2.5 cm were killed,

with maximum intensity fires it was 7.5 cm and with prolonged heavy fuel fires it was 20 cm. French and Keirle (1969) found that although ants were destroyed along with other insects during fire they were among the first recolonisers and ant population appears to increase post fire. Clinnick (1984) notes two trends; firstly that the impact is greater in forested areas than in grasslands due mainly to the greater fuel supply and more intense burns, and secondly that populations are not only affected by the fire but are reduced by changes in the environment after fire also.

Soil loss

Soil losses after fire are due to lack of vegetation which normally binds and protects the soil. In the sandstone area around Sydney after fire Blong, Riley and Crozier, (1982) found soil losses could amount to 20 t ha^{-1} y^{-1}.

Steady state accumulation of litter

Litter accumulation after fire has been examined in a eucalypt forest at Seal Rocks, NSW (Fox, Fox and McKay, 1979). It was found that steady state accumulation of litter (1.67 kgm^{-2}) was reached after 10 years. Lamb (1985) found that forest floors in the Narrabeen Lagon area attained stability, with no acretion of litter 9 years after fire.

Conclusions

Both the temperature reached during a fire and the effect this has on soil fauna are important considerations when the plant opal cycle is considered in Australia. The high temperatures required to change the mineralogy and physical characteristics of the opal may be attained under very special conditions during a fire. Soil fauna are important in moving plant opal around on the surface and in the soil, and their loss or modification to the species present may affect the plant opal assemblage in various parts of the soil material.

APPENDIX E

THE SILICA CYCLE

Introduction

This Appendix examines the terrestrial silica cycle and concentrates on particulate silica. The transfer of elements between the living and the non-living has been the subject of study for over a century. The focus of this interest has been on the cycling of nutrients between parts of ecosystems; however the use of the term "nutrients" carries with it connotations of energy transfer. Biogeochemical cycles encompass the cycling of those elements which have been shown to be of nutrient value as well as those for which a purpose is not fully understood, such as silicon. While there has been much research into the accumulation and cycling of calcium, magnesium, potassium, etc., very little of the terrestrial silicon or silica cycles have been examined.

The cycling of elements involves inputs, outputs and turnover/retention. The main input processes are wet deposition, dry deposition (the direct transfer of gases and particles from the atmosphere), nitrogen fixation and mineral weathering. Most are poorly understood, complex and difficult to quantify. Losses are to the soil solution, as particulate material transported by wind or water, as gases and in harvested crops. There is a need to determine losses in all forms of a given element and to consider temporal and spatial variations. Major losses may occur, for example, during extreme events. Retention may occur in both plants and the soil, and the turnover or transfer between different parts of the ecosystem again are not well understood. Different compartments are often studied in isolation and in particular the transfer of elements from litter to soil has been intensely studied. However, it is easier to describe in systems in steady state than in those which are in a state of change as is often the case.

Most studies follow the transfer of a single element, however, many biological systems concentrate minerals - naturally occuring substances such as $CaCO_3$ in the form of calcite or aragonite and SiO_2 in the form of opal. Opaline silica is deposited by radiolaria, diatoms, siliceous sponges and silicoflagellates which, upon death, contribute to the siliceous oozes on the ocean floor. In addition, the silica from terrestrial plants enters rivers, thus contributing to the concentration of silicon in oceans. The silica cycle can be considered a sub-set of the silicon cycle. This Appendix examines the terrestrial silica cycle and what is known of the processes involved in the cycle.

Biomineralization

Biomineralization is the process by which minerals are produced by organisms. The biological precipitation of calcium carbonate is probably the best studied of these phenomena, however the role of organisms in the cycling of silicon and the effect of microorganisms in the distribution of heavy metals in the environment have also been examined in some detail (Westbroek and De Jong, 1983).

The relationship between organisms and the environment is often considered passive - that is the organisms adapt to environmental changes in a passive way. The gaia hypothesis sees organisms as actively keeping the environment optimal for life (Lovelock, 1983). While this hypothesis originally considered the atmosphere, it has been extended by Margulis and Stolz (1983) to include surface sediments. Such studies are in their infancy; silicon is one of the most abundant elements and the reasons why organisms concentrate it are not fully understood.

(i) The take-up of silica

Lovering and Engel (1967) used crushed raw sterilized basalt, rhyolite and quartz diorite as growing mediums to examine the way silica moves into *Equisetum* and three grasses. Water draining from the pots was collected and reused, and only demineralised water and measured nutrients added. Sap and leaves and stalks were analysed. They found that the plants "solubilized" the solid silica in the rocks and made it available for the plant. They quoted the work of Keller and Fredrickson (1952) who pointed out that the roots of plants carry a strong negative charge so are able to exchange hydrogen ions for cations in the soil and rock.

Lovering commented that "a forest of silica accumulator plants might extract about 2,000 tons of silica per acre in 5,000 years, which would be equivalent to the silica in one acre foot of basalt" (1958:1061).

(ii) Deposition in plant tissue

The mechanism of silica deposition in the higher plants, particularly the Gramineae has been extensively studied (i.e. Sangster, Parry and Rees, 1983 a and b; Hodson *et al.* 1984; Hodson and Sangster 1988, 1989, 1990). Hodson and Sangster (1988) commented that the two common features of deposition in wheat were that silica is deposited on the outer surface of the bracts and that trichomes are also major sites of deposition. Sangster and Hodson are presently using recent developments in x-ray microanalysis to study soluble silicon and the ionic environment at depositional sites (1990).

Inputs

The input of plant opal to the cycle is from the plant via the litter, or via transported material in the air or water including dust containing plant opal, litter and animal faeces.

Bartoli (1983) concentrated on the biological side of the cycle i.e. uptake by plants and return to the soil via litter fall, etc. His work was conducted in the Vosges Mountains in northern France on Triassic Sandstone in a deciduous forest and a coniferous forest. He erected a simple model showing the flow of silicon and established a silicon budget.

Litterfall from tree layer was collected in 1 m^2 sieves, from herbaceous layers it was estimated by cutting the entire herbaceous layer inside 1 m^2 squares in Autumn and estimating an average residence time of 2 years. Bartoli did not state how he calculated vegetation uptake in any detail but appears to have added woody production of silicon, needle and litterfall.

Outputs

Plant opal is removed in dust and smoke, by litter, in movement in water, by animals, and is dissolved in the soil. Dissolution of the plant opal, particularly in the very small size range, possibly makes a substantial contribution to the soil water, but this is a point which requires research.

Storage

(i) The amount of plant opal in plants and litter

Geiss (1984) found the particulate silica standing crop in two forest types were 54.26 kg/ha (red pine [*Pinus resinosa* Ait] plantation) and 90.11 kg/ha (sugar maple [*Acer saccharum* Marsh]).

Witty and Knox (1964) examined phytolith production on the grasslands of Oregon. They estimated that, in the 15 - 100 um size range, 20 - 30 lbs/acre/yr (22.5 - 33.5 kg/ha/yr) was added to the soil. This was based on a production rate of 1,000 to 1,5000 lbs/acre/yr of grass.

Jones and Beaver (1964b), working on a production rate of 5,000 lb/acre/yr (grass), calculated that 3% by dry weight of this was plant opal i.e. 150 lb/acre/yr. (168 kg/ha/yr). They estimated that 10% of this was in the 50 - 20 um size range.

(ii) The amount of plant opal in soil

The quantity of plant opal deposited in soils on an annual basis has generally been estimated using the following steps:-

1. Vegetation production. Usually in a monocultural situation, i.e. grasslands, etc. A figure for vegetation production/area/annum is obtained but its derivation is not often explained.
2. The percentage by dry weight of the plant opal in the vegetation is then calculated.
3. This gives an estimate of per annum plant opal addition.

Actual measurement of the total plant opal in the soil is difficult (see Appendix F and Chapter 6) but such figures have been used to estimate the persistance of plant opal in the soil and, with estimates of plant input, the age of the soil. These estimations do not take into account dissolution, the difficulty of estimating the amount of opal in the clay fraction, redistribution by fauna; including accumulation and withdrawal from the cycle (for example in termite mounds), redistribution throughout the soil profile, removal to the surface for redistribution by surface processes and removal before incorporation into the soil by wind, rainwash, etc., particularly after fire.

In calculations of accumulation rates the percentage weight of plant opal in a particular soil fraction is multiplied by the percentage of that fraction in the total soil, or, in the case of some workers (i.e. Witty and Knox, 1964) calculations are based on one soil fraction only (in this case the 15-100 um). Witty and Knox (1964) estimated that

4-7,000 years were required to accumulate the phytoliths found at their sites in north central Oregon. They contended that weathering loss by reduction of particle size and partial transformation to chalcedony were adequately covered by 10% of their phytoliths being smaller than 15 um, (an under-estimation, surely), and since the 15-100 um soil fraction constituted 28.2-41.7%, a large clay fraction may have been present containing phytoliths, thus further giving rise to a potential source of error.

Jones and Beavers (1964a) examined the catenary and depth distribution of phytoliths and found the maximum phytolith content to be in the mid-slope area which they related to higher productivity at these sites. They used plant opal accumulation rates which are open to question (since only part of the soil material (5-50 um) was examined), to date vegetation changes in the area. Similarly Jones and Beavers (1964b), Witty and Knox (1964), Verma and Rust (1969) and others, have attempted to reconstruct paleo-environments using rates of accumulations of plant opal, much of which seems highly speculative.

There is evidence that phytoliths may persist in the near surface environment for long periods of time. Baker (1959c) identified phytoliths in Cainozoic and Quaternary sediments and commented that "the process of phytolith generation by plants was not restricted to modern times" (1959c:306) but require special circumstances to be thus preserved since they did not normally survive in the present soils for much longer than 1,000 years. This figure of 1,000 years was based on Baker and Leeper's (1958) contention that otherwise phytoliths would be present in greater quantities than the 1 or 2% content they had found in Australian soils. In light of the removal of plant opal during processes after fire reported in this thesis, these figures need revision. In Baker (1960c) phytoliths are reported in Tertiary and Quaternary sediments in Victoria, surviving without becoming severely corroded or transformed into chalcedony or quartz. Similarly, phytoliths have been reported in Tertiary rocks by Jones (1964) and Gill (1967).

The cycling of plant opal

A basic silica cycle is presented by Jones and Handreck (1967). Monosilicic acid in the soil is taken up by plants and deposited as opal. This is returned to the soil on the death of the plant, either directly or through the alimentary canals of herbivors. The decay of these sources leads to the deposition in the soil of discreet opaline particles which form an important source of the monosilicic acid for subsequent cycles.

Pease (1967) in an examination of the usefulness of phytoliths in recreating vegetation history and identification of paleosols also presented an opal phytolith cycle which may be summarized as

1. a calculation of the annual production of phytoliths in black grama, both from above ground and below ground
2. wind deflation leading to fragmentation of the phytoliths, and leading to the loss of all the clay size and less than one micron thick phytoliths from the above-ground part of the plants [note that he did not appear to actually look for phytoliths in this size range]
3. since all the soil phytoliths observed were over 9 microns thick, he assumed small phytoliths had dissapeared from the soil, and that the larger phytoliths had also been subject to some dissolution

4 based on figures obtained from the above he calculated that it would take 50 years to accumulate the amount of phytolith

material that he had found in the A horizon of one of the soils examined

Point 2 suggests that the plant opal in this size range is in some way released from its encompassing vegetation before incorporation into the soil, but Pease didn't discuss a mechanism for this.

Bartoli (1983) erected a model for the biogeochemical cycling of silicon for two forest communities in France. Details of calculations of the various fluxes were omitted. Trudgill (1988) presented a general model for the ecosystem geochemistry of silica (1988:fig 7.14, p134). As far as the plant/weathering cycle was concerned, he distinguished three main forms of silica - quartz, silicate minerals, and amorphous silica and noted that silicon could be present in solution as silicic acid. Trudgill pointed out that plant uptake and retention of silica could influence the amount of silica found in streams due to the form in which it is returned to the soil being not readily soluble. The solubility of phytoliths appears to be greater than that of the primary silicate minerals but less than that of amorphous silica and he envisaged two roles for phytoliths in silica mobility; mobilisation and leaching would be aided since the silca from the original minerals is returned to the soil in a more soluble form, and uptake from amorphous silica could result in the return of phytoliths which are less soluble. Trudgill regarded the phytoliths as a store of silica (as demonstrated by his fig 7.14) with their only output being a secondary route for reuse by plants and output in drainage. There appeared to be no connection between the phytoliths and the soil solution.

A model for plant opal cycling

A general model for the cycling of plant opal can be erected in which inputs, outputs and storages can be identified. It is the amount in each store and the processes by which it is moved between the stores as well as in and out of the cycle which are of interest (Figure E1).

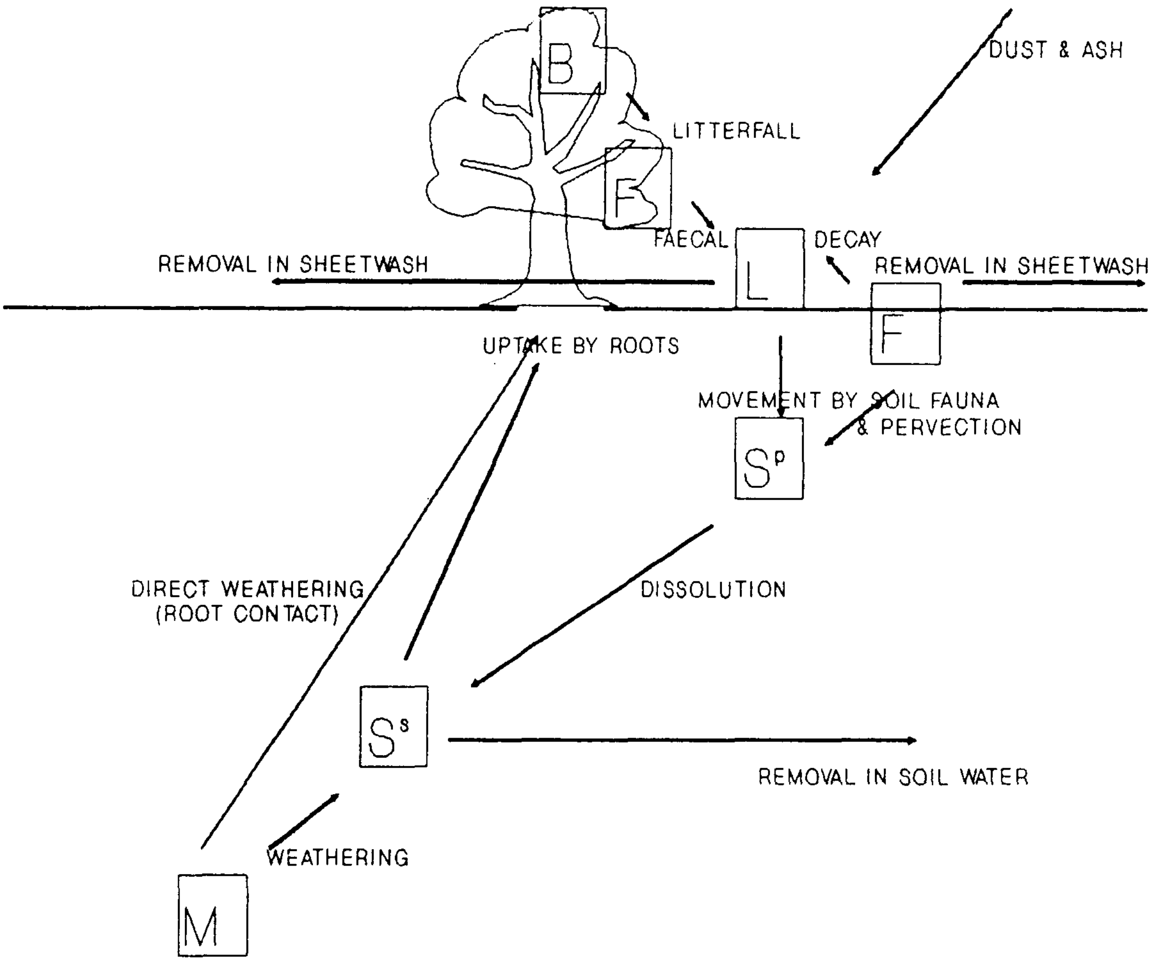
(i) Movement between stores

Movement between the plant and the litter layer, litter layer and the soil has not been examined in any detail. Litter is incorporated into the soil by fauna. Losses may occur via water movement laterally over the surface removing litter and soil and by the removal of dust containing exposed plant opal. During fire losses may occur in smoke.

Once incorporated in the soil the transport mechanisms moving plant opal are not known. There is considerable debate as to the mobility of plant opal vertically in the soil, and the role of soil fauna has not been examined. Losses may occur through dissolution and through the exposure of soil on the surface by soil fauna.

(ii) The intervention of fire

Figure E2 models the cycling of particulate opal after fire. In this case the removal of plant opal in sheetwash and smoke is considerable. Movement between the litter and faunal stores is temporarily interupted, and uptake by the roots may take some time to be re-established. There is a ~~nett~~ loss of particulate silica from the system.



KEY

B	BIOMASS STORAGE	S^p	SOIL PARTICULATE OPAL
F	FAUNAL STORAGE	S^s	SOIL SOLUTION
L	LITTER STORAGE	M	SILICATE MINERALS

FIGURE E1: MODEL FOR THE CYCLING OF PARTICULATE OPAL

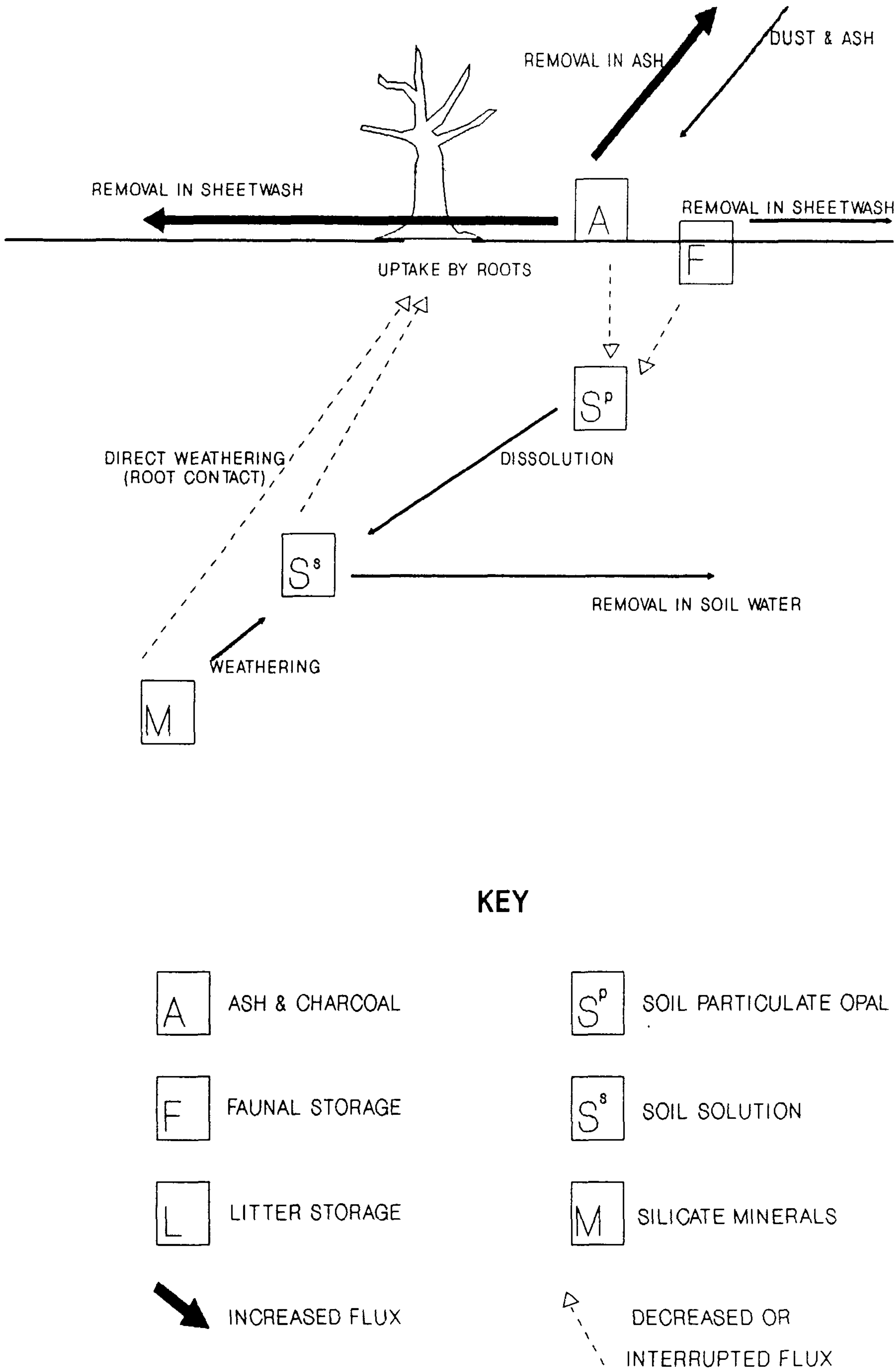


FIGURE E2: MODEL FOR THE CYCLING OF PARTICULATE OPAL AFTER FIRE

APPENDIX F

SAMPLE PREPARATION TECHNIQUES

Introduction

The general techniques used to separate plant opal from plants and sediments are discussed in this Appendix, and the specific techniques used, unless covered in Chapter 7, are outlined.

A: Sample Preparation

(i) Overview of techniques

1. Extraction of plant opal from plants

The examination of plant opal may be for one of two purposes; either (i) morphological or (ii) to collect for further experiments. In the first case, the morphological study may be of the *in situ* plant opal, that is the plant opal in its growth position, or it may be of the plant opal shape itself, in which case the extraction techniques used will be similar to those used in (ii). In the case of the study which wished to examine the plant opal in growth position, the term "extraction" does not really apply.

(i) The *in situ* examination of plant opal

In this case the operator wishes to examine the undisturbed cells in which the opal is found, free of any extraneous material. The methods used include spodograms (dry ashing), epidermal peels and microtome sections.

(a) Spodograms

Spodograms are made by dry ashing the plant material in a furnace. This method is fully outlined in Chapter 7.

(b) Epidermal peels

Epidermal peels are made by scrapping away the leaf tissue from the epidermal layer of the leaf with a blade after maceration by acid. The peel is then dehydrated and mounted. Variations of this method include the various treatments made to clear tissue using, for example, ammonia and hydrogen peroxide and chromation (Parry *et al.*, 1984).

(c) Microtome sectioning

This is a method which employs the air drying or freeze drying of samples which are then sliced thinly, often stained (Dayanandan *et al.* 1983) and then mounted for Scanning Electron Microscopy (SEM), light microscopy, etc. (Geis, 1977; Bennett and Wynn Parry, 1979). Hodson and Sangster (1990) comment that these methods and the use of glutaraldehyde/osmium tetroxide fixation for Transmission Electron Microscopy (TEM) are suitable for material being prepared for the study of the deposited form of silica. The development of new preparation techniques for the study of the soluble, mobile forms of silica include the use of Energy Dispersive X-ray (EDX) microanalysis on a cold SEM stage and freeze substituted sections in TEM or SEM.

(ii) Disarticulated plant opal extraction

The extraction of disarticulate plant opal may be by "dry-way" (spodograms, discussed above) or by "wet-way". Digestion by acids and oxidation by various agents is used in the wet-way method. The more recent of these methods are summarised in Table F1.

2 Extraction of Plant opal from sediments

(i) Whole sample

Separation from the whole sediment sample, although desirable, is not simple due to the flocuation tendencies of some clays. This means that the plant opal cannot be extracted with any degree of purity from the clay fraction, and this is a problem since it is believed that most of the plant opal is in this size range (Wilding and Drees, 1974).

It was suggested by Jones (1969) that dissolution by alkaline solutions might be one way of estimating the overall opal content in a soil. Jones boiled the 20-50 um fraction of a soil for 20 minutes in

Table F1: WET WAY SILICA EXTRACTION FROM PLANTS; SUMMARY OF METHODS

Pre-treatment	Oxidising agents	Other steps	Reference
wash/HCl	Schulze soltn*	centrifuge, wash & decant	Rovner 1972 Geis 1978 Wilson 1982 Mulholland 1984
boil acetone/ether bath chloral hydrate	Schulze soltn*	centrifuge, wash & decant	Rovner & Noguera 1986
wash	Schulze soltn*	wash in HCl, water & acetone	Piperno 1983**
Alconox soltn then HCl	Schulze soltn*	heat, wash add KOH, wash	Rattel 1984
		add pottasium chlorate & wash in HCl, water & acetone	Piperno 1987
wash then sonicate dry	chromic-sulfuric acid	wash then wash in ethanol	Kaplan & Smith 1980
wash	sulfuric acid & hydrogen peroxide	wash in HCl	Geis 1973
		wash in alcohol	Klukkert 1987
predigest in nitric acid	ternary acid mix	wash in HCl water and ethanol	Piperno 1987
hydrogen peroxide	potassium dichromate	wash in water	Jones 1988
wash in water, dry	sulphuric acid & chromium trioxide	wash in water	Hart 1988a

* nitric acid and potassium or sodium chlorate

** in Pearsall 1989

0.5N sodium hydroxide and found results comparable to the liquid density separation method discussed below. Jorgensen (1970) used a similar method in the study of Cretaceous flints, and found quartz to be attacked slightly while crypto-crystalline silica dissolved rapidly. Wilding and Drees (1974) boiled the 5-20 um opal isolates of tree leaves for 2.5 minutes in 0.5N sodium hydroxide and found between two thirds to three quarters of the total opal isolate dissolved, compared with only one third of the grass opal specimen of Jones (1969) in 20 minutes, suggesting a different rate of dissolution of forest opal by a factor of 10-15 and reflecting the differences in morphology between the two types. While such experiments have been confined to the 5-20 um fraction, it may be possible to use similar techniques to calculate the opal present in the difficult clay size fraction.

(b) Silt size and larger

The low specific gravity of opal (1.5 to 2.3) makes it possible to separate plant opal from the sand to fine silt range in sediments. Heavy liquids are used after any organic material has been removed using peroxide or by heating in chromic acid, salts, etc. removed and the soil dispersed by the use of Calgon (i.e. Wilding, 1967) or a 9% polyvinylpyrrolidone solution in ethanol (i.e. Wilding and Drees, 1974). The size fraction required is then separated out by the usual fractionation methods.

Table F2 outlines various procedures which are used to eliminate unwanted materials which restrict the subsequent opal yield. The opaline material is then separated by the usual heavy liquid methods utilizing a heavy liquid such as nitro-benzene bromoform at a specific gravity (SG) of 2.3 (see Table F3). Such methods are time consuming and often the yield is low. Indeed, Wilding commented that in order to

Table F2: PRE-TREATMENT OF SEDIMENTS - DEFLOCULATION & SEPARATION

Material	Method	Reference
clay	deflocculate then gravity separation deflocculants: sodium hexametaphosphate	 Mulholland 1983 Twiss et al 1969 Rovner 1971 Carbone 1977 Piperno 1983
	sodium bicarbonate	Piperno 1987
sand	wet seiving	Piperno 1987 Pearsall 1989 Carbone 1977
organic material	heat at 350 deg C 24 hrs	Huber 1986
	nitric acid	Piperno 1987
	hydrogen peroxide	Piperno 1987 Carbone 1977 Pearsall 1989
	nitric acid & pottasium chlorate	Piperno 1987
	nitric-perchloric acid	Rovner 1971
	Schulze solution	Pearsall 1989
humic colloids	pottassium hydroxide	Piperno 1987 Pearsall 1989
carbonates	10% HCl	Mulholland 1983 Piperno 1987 Rovner 1971 Pearsall 1989

Table F3: HEAVY LIQUIDS USED IN PLANT OPAL SEPARATION

Heavy Liquid	Problems/Advantages	Reference
Bromoform-acetone	carcinogen	Knox 1942 Oberholster 1968
Bromoform-nitrobenzene	carcinogen	Jones 1964 Jones & Beavers 1964a Wilding 1967 Wilding & Drees 1974
Bromoform-tetra-chloromethane	carcinogen	Twiss et al 1969 Yeck & Gray 1972
Bromoform-tetralin	carcinogen	Smithson 1958
Ethanol-bromoform	carcinogen	Kalisz & Stone 1984
Potassium iodide-cadmium iodide	not carcinogenoic and no noxious odour	Carbone 1977 Piperno 1983
Tetrabromoethane-nitrobenzene	fumes	Yeck & Gray 1972
Tetrabromoethane-ethyl alcohol	fumes	Rovner 1971
Toulet's solution		Kondo & Iwasa 1981
Zinc Bromide	zinc precipitates progressively darkens	Wilson 1982 Bowdery 1984 Mulholland 1984 Hart 1990
Sodium Polytungstate	non-carcinogenic no fumes	Hart 1990

fractionate and purify approximately 75 g of opal from 45 kg of soil for radiocarbon dating purposes, "laborious and time-consuming procedures were employed" (1967:66). Heavy liquids are often deleterious to health. Hart (1988b) reports on the use of sodium polytungstate, which is reputed to be harmless. This method is discussed in Chapter 7.

(iii) Separation by other methods

Powers and Gilbertson (1987) outlined a method for the extraction of plant opal from sediments. They used hydrochloric acid to disaggregate the sample and dissolve carbonates, centrifuged in water and then methanol to clean and dry the sample, ignited it in methanol, then mounted the material in Canada Balsam after the addition of a tracer aliquot. Absolute frequencies can be made with this method.

(iv) Problems

The problems encountered during processing of sediments are admirably discussed in Pearsall and Trimble (1983). These range from chemical reactions between various chemicals used to remove clays, organic material etc., to supernatant liquid being trapped both above and below a soil wedge. What must be stressed is that the result is to concentrate the opal rather than separate it entirely from its surrounding sediment. In addition, the opal is a mixture of opal derived from plants, diatoms and other silica concentrating organisms which may be present in the sediment.

(ii) Mounting

Once the sample of plant opal has been obtained, it is mounted for examination. The method used will depend largely upon the technique being used to examine the opal and whether the opal is disarticulated or in an *in situ.* sample. The main mounting techniques used for the examination of disarticulated samples are examined here.

For these samples the more common requirements are for scanning and counting of the opal using SEM, TEM and light microscopy. All techniques require that the sample be representative, evenly distributed and that neither too many nor too few opal bodies are on the mount. Such problems are overcome by standardising mounting procedures, such as utilising a standard scoop for dry plant opal (Pearsall, 1989) so that slides contain an easily read amount of opal. The use of mounting mediums such as Canada Balsam may cause zonation of the opal, with concentrations on the edges of the medium and size zonation radially from the centre. Standardised scanning procedures will overcome such problems.

1. Light microscopy

For light microscopy, the refractive index (RI) of the opal (around 1.4) is utilised to provide a greater relief for the particles by mounting them in media having a higher RI (Table F4). Some workers prefer to use media in which the opal may be rotated such as glycerine, oil, benzyl benzoate and styrene. Opal is placed on the slide, either dry or in a liquid (ethanol, water) which is then dried, the media added and the slide covered with a cover slip and labelled. Since opal is isotropic, all light is suppressed when it is viewed by polarised light and thus identification of the opal may be made.

2. Scanning Electron Microscope

Fixing the opal to aluminium or carbon stubs for SEM and X-ray analysis is relatively simple since the opal tends to adhere to the stub without the necessity to use an adhesive. Microstik (Pearsall, 1987), Black Wax W (Hart, 1988a), double-sided tape (Lanning *et al.*, 1980), silver paint (Brandenburg *et al.*, 1985) and polystyrene (Sangster, 1983) have also been used. The coating material used is usually gold, although carbon and gold-palladium alloy is also used (see Bowdery,

Table F4: MEDIA USED TO MOUNT SILICA FOR LIGHT MICROSCOPY

Mounting Media	Comments	Refractive Index	References
Cadex		1.55	Twiss et al 1969 Parmenter & Folger 1974 Carbone 1977
Canada balsam		1.54	Parry & Smithson 1957 Baker 1959b Metcalf 1960 Jones et al 1963 Witty & Knox 1964 Mehra & Sharma 1965 Rovner 1971 Clifford & Watson 1977 Pearsall 1979 Lanning & Eleuterius 1987
Canada balsam & benzole			Parry & Smithson 1958a
Cedarwood oil		1.51	Parry & Smithson 1958a
Clove oil		1.53	Baker 1959b
Eukitt		1.5	Bowdery 1984 Hart 1990
Euparol		1.48	Parry & Smithson 1958a
Glycerine jelly		1.47	Palmer 1976
Gurr's medium		1.51	Parry & Smithson 1958a Jones et al 1963
Permount		1.54	Geis 1973 Klein & Geis 1978 Mulholland et al 1982 Piperno 1983 Brown 1984
Phenol		1.55	Metcalfe 1960
Styrolite			Powers & Gilbertson 1987

1989). The identification of opal may be made by wave length dispersive X-ray analysis or electron probe microanalysis.

(iii) Methods used in this thesis.

1. Extraction from plants

The method used in this thesis is as follows:

(i) Fresh material is carefully washed several times in distilled water and absolute alcohol to remove adhering matter.

(ii) The sample is cut up to small pieces (5 mm^2) and oven dried to desicate.

(iii) Subsamples (weighed for quantitative work) of around 1 to 3 g are placed in a 500 mL glass beaker which has been thoroughly washed in distilled water and oven dried. Approximately 200 mL of concentrated sulphuric acid is poured into the beaker to macerate the organic material. This is stirred with a clean glass rod occasionally and left around 24 hours. If the material is not completely macerated after 24 hours, more concentrated sulphuric acid is added.

(iv) A 50% solution of chromium trioxide in distilled water is added slowly until boiling stops and oxidation is complete.

(v) 200 mL water is added, and the solution centrifuged using a Clements GS 200 Centrifuge at 2,000 r.p.m. for 10 minutes. The supernatant is carefully drawn off, leaving the plant opal in the bottom of the tube. The tubes are filled with distilled water and the process repeated until the opal is clean - this often requires 10 to 11 repeats.

(vi) The plant opal is either dried using acetone or heat, or stored in distilled water.

2. Extraction from sediments

The two methods used to concentrate plant opal in sediments have been outlined in full in Chapter 7.

3. Mounting of samples

(i) Light microscopy.

Samples were mounted for light microscopy using Canada Balsam (RI=1.54) or Eukitt (RI=1.51) as the mounting media on glass slides. In either case the placing of the sample on the slide was achieved the same way. The plant opal for morphological examination was stored in glass or plastic vials in water. The vial was shaken to suspend all of the plant opal in the water, then a drop of the suspension was quickly removed using a pipette. Experience showed the amount of water needed to provide a good result. This was dropped onto the centre of the slide and the water allowed to evaporate naturally without the slide being disturbed in order to minimise clumping and zonation.

The Canada Balsam was added by heating the slide gently on a hot plate and dropping a piece of the media onto it and allowing it to melt and cover the sample. A cover slip was carefully applied from one side, and the slide labelled and left to harden. It was found that the necessity for melting the Canada Balsam occasionally led to the samples becoming disturbed and re-organsised, often in concentric zones.

The Eukitt was simply dropped onto the labelled slide, a cover slip applied and left to harden for 48 hours. It was found that the concentric zoning problem was eliminated. If the Eukitt was not at the right consistency, the addition of a few drops of acetone was needed.

Both media gave reasonable results with the opal appearing in high relief when viewed under a light microscope. Under crossed nichols, opal is isotropic, leading to ready identification of opaline particles. Counting was done at a magnification of 500X, with transects being made completely along the slide to eliminate the possibility of sample bias due to disturbance by the media.

(ii) Scanning Electron Microscopy

Aluminium stubs were coated with Black Wax W (Finch, 1974) as this provides a matt black background for photography against which the plant opal shows clearly. The wax was applied by heating the stub in a bunsen burner, and applying the stick of wax to the surface, coating the stub. This was then left (covered) for 12 hours to harden and completely cool, since if the samples are added while the wax is soft, they sink into it and are obscured.

The sample was added to the stub in the same way as to the glass slides (see above). The stub was left under cover (to protect it from dust) until the water had completely evaporated. Occasionally, rapid evaporation led to the plant opal being concentrated around the perimeter of the stub, causing overcrowding. However, it was generally found that this method left a layer of plant opal on the surface of the stub which was not too concentrated.

The stubs were then coated with gold to a thickness of 2 angstrom units using a polaron Diode Shutter-coater. They were examined using a Jeol Jsm-T 20 Scanning Electron Microscope used in the secondary electron emissive mode and the back-scattering mode. The accelerating potential used was variable.

B: Analysis techniques

Introduction

In this thesis, the techniques used to analyse plant opal material fall under three headings: (i) percentage content in sediment and plants; (ii) plant opal morphology and assemblage analysis; and (iii) surface area.

(i) Percentage content of plant opal by weight

1. Plant material

In this instance the plant material is dried to constant weight and the plant opal extracted using the method discussed in the previous section. The plant opal is dried, weighed and the weight of opal is expressed as a percentage of the plant material it was derived from (dry weights). In most cases three replications were done, and the results expressed as an average percentage with standard deviation.

2. Sediments

(a) Background

The amount of plant opal present in a sediment is expressed as a percentage of a size range of the sediment from which it was extracted. Traditionally the silt fraction of the sediment has been utilised in such calculations, since the clay fraction presents difficulties in extraction and the sand fraction contains fewer of the plant opal particles considered as diagnostic (i.e. the grass opal).

During the 1960s and 1970s, such calculations were commonly made in simplistic attempts to co-relate the amount of plant opal in a soil with the age of the soil and/or with changes in climate and vegetation. In particular the loess areas of the United States provided the source areas for this research (Beavers and Stephen, 1958; Jones and Beavers, 1964a,b; Wilding and Drees, 1971).

Two main methods have been used to obtain the percentages. Witty and Knox (1964) examined the whole soil contained in one size fraction mounted on slides. The percentage was based on counts of up to 2000 grains per sample, that is to say it was the proportion of identified opal on the slide. This method was also used by Beavers and Stephen (1958) and Dormaar and Lutwick (1969).

Yeck and Gray (1972), weighed the plant opal obtained from a size fraction utilising heavy liquid separation and adjusted this weight by a purity factor obtained by grain counts under a microscope. A similar method was used by Verma and Rust (1969), Wilding and Drees (1971) and many others. It is the method which has been used in this thesis.

(b) Method used

All weighing was carried out on a Mettler H 315 balance which weighed to 4 decimal places.

(i) Sediment

The sediment size fraction used was the 2-8 phi (fine sand to very fine silt [Wentworth Size Class], 250 to 3.9 microns). Plant opal was concentrated, dried (using acetone generally to avoid clumping) and weighed. Slides were then made of the opal made using the methods outlined earlier in this Appendix. Purity was assessed by counts of 200 particles and expressed as a proportion with a standard error at the 95% level ($SE(P)=[P(1-p)/n]^{-2}$). Lists of the slides and their purity are to be found with the sediment data in Appendix G.

(ii) Litter

Similarly, after extraction and drying, slides were prepared of the litter extracts of plant opal, and their purity assessed by the above method. The list of slides and their purity is also to be found in Appendix G.

(ii) Plant opal morphology and assemblage analysis

(i) counting

There are two counting procedures used for characterising the plant opal in a sample; absolute and relative. The relative or percentage method was used in this thesis.

Slides of the material to be analysed were prepared using the method outlined in Chapter 7. A Leitz Petrological (polarising) binocular microscope was used in conjuction with a Swift (Model F) counter. Scanning began at one edge of each slide and continued in rows 1 mm apart. The counter was set at a 0.2 mm stage interval, and the magnification was 400X.

Opal was identified using its optical properties:

1. Refractive Index (RI)

The RI of opal is 1.41 - 1.47. It can be assessed by looking at relief and the Becke-line test. The relief of opal is low in the mediums used and the Becke line moves into the medium when the distance between the objective and the slide is increased.

2. Isotropisim

Opal is isotropic, thus in cross-polarised light it appears black.

3. Colour

Colour varies considerably from brown/black to clear. It is dependant upon thickness, ornamentation and occluded elements within the opal.

4. Shape

While some plant opal (phytoliths) present shapes which mark them as biological (i.e. they imitate the shape of a plant cell), most is of an irregular shape, thus shape alone cannot be used as an identifier.

Once identified as opal, the particle was placed in a category according to the Key (see Chapters 9 and 10). This was not an easy task, since these are three dimensional objects which are viewed in two dimensions. Each category or "morphological type" was given a number which was consistent for all assemblages except those erected from the acacia. The morphological type and number used in assemblage diagrams are to be found in Table 5.1 and Table 5.8.

A scanning form was used and 200 opal grains counted. This number was arrived at by examination of slides of plant opal derived from various species and counting plant opal on each one until new morphological types were no longer found. It was found that this number consistantly accounted for all of the shapes in a sample. A typical example is illustrated in Figure F1, where, after 160 pieces of opal had been counted covering 16 morphological types, no further shapes were found.

(ii) Presentation of results

There have been many different ways of presenting the results obtained. Tables, pollen diagram format and cumulative frequency curves are the more common methods (Piperno, 1987). The cumulative frequency curve was used in this thesis since it was simple to prepare and diagrams were easily compared.

Construction of the cumulative frequency curves was based on the data obtained by counts. For each sample, a table was prepared and the information graphed using a LOTUS 123 Graphics program.

(iii) Interpretation of results

Very little use has been made of statistics in the interpretation of plant opal data. Much of the work is aimed at establishing a correspondence between various assemblages, and such relationships have been made by eye rather than quantitatively. Pearsall (1987) reports that Chiswell (1984: not sighted) in a Masters Thesis, used the Kolmogorov-Smirnov two sample test on pairs of phytolith cumulative frequency curves to test their similarity. This tests whether or not the two samples could have come from the same or identical populations, is independent of any assumptions about the underlying forms of the population distributions and can be used on small sample size (Cheeney, 1983).

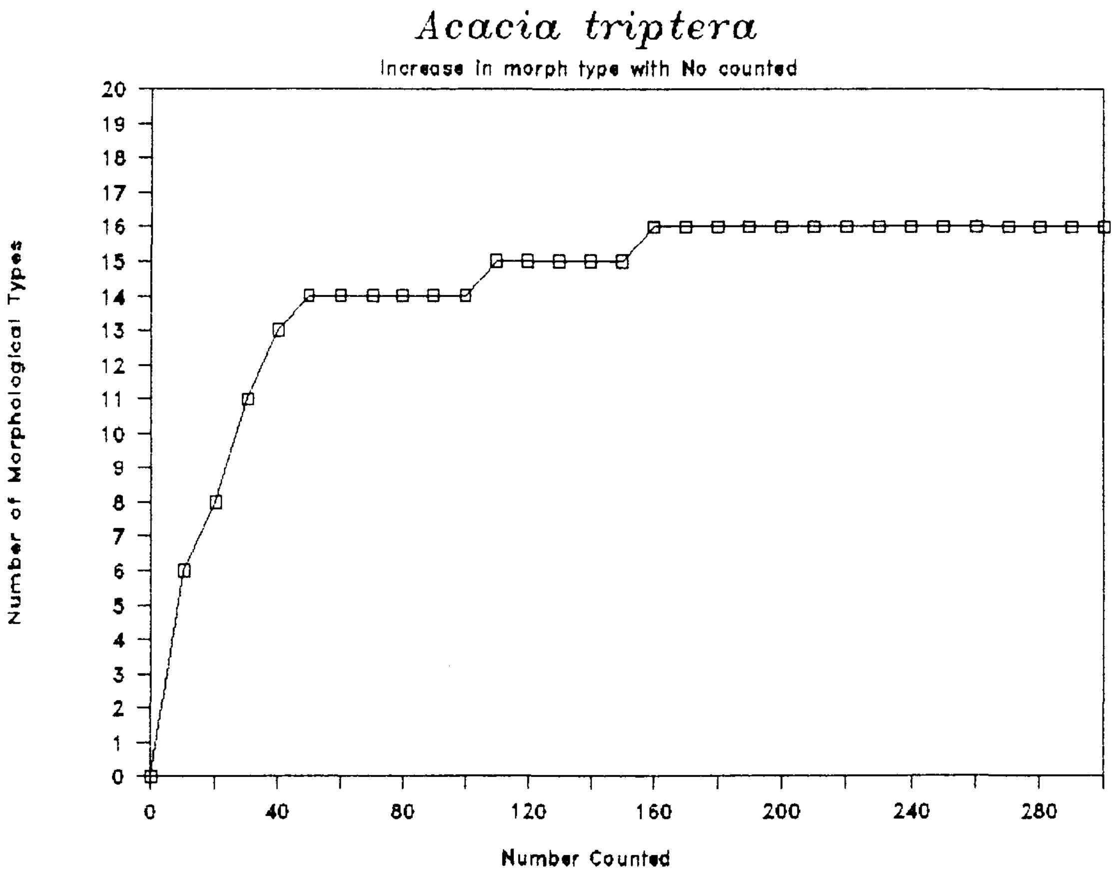


FIGURE F1: SAMPLE SIZE REQUIRED IN POINT COUNTING

For the purposes of comparing plant opal cumulative frequency curves, the null hypothesis is that the two samples were drawn from identical populations and that discrepancies are due to sampling. The alternative hypothesis is that the samples are drawn from different populations. The test statistic D is the maximum discrepancy measured on the vertical scale between the two curves (curve 1 percentage minus curve 2 percentage, regardless of sign). The critical values of the Kolmogorov-Smirnov test statistic D (two-tail test) are $1.36N^1$ ($a=0.05$) where $N^1 = [(N_1 + N_2)/(N_1 \times N_2)]^{-2}$. [$N_1$ and N_2 are the size of the first and second samples.]

This test was used throughout the thesis in order to compare plant opal assemblages erected. It was done to provide some consistent measure of the similarity or differences between assemblages.

(iii) Surface Area

Where the surface area of particles was required, a graduated scale on the microscope eyepiece was used and each particles length and average width recorded. The degree of carbon coating, which was also recorded, was assessed.

APPENDIX G: DATA SHEETS

Introduction

This Appendix contains:

1. Grain size analysis data sheets.

2a. Scanning sheets for assemblage work: this is the raw data collected from point counting, and includes the calculations for the assemblage diagrams.

2b Data for the Kolmogorov-Smirnov two tail tests applied to the plant opal assemblage diagrams.

3. Data for the Ecology Reserve ash surface area graphs.

4. The distribution of plant opal in soils (used in graphs).

5. Point counting data for purity of extractions.

6. Detailed data for percentage faunal channels with depth.

7. Codes of samples held in the Museum of the School of Earth Sciences, Macquarie University.

Table G1: PARTICLE SIZE DISTRIBUTION
SWAMP CORE (OFC1), OXFORD FALLS
DRY SEIVING AND PIPETTE ANALYSIS

Size phi	Raw Weight g	Weight %	Cum Wt %
-0.50	0.21	0.71	0.71
0.00	0.31	1.04	1.75
0.50	0.73	2.46	4.21
1.00	1.58	5.32	9.52
1.50	4.68	15.75	25.27
2.00	4.76	16.02	41.29
2.50	4.42	14.87	56.16
3.00	3.07	10.33	66.49
3.50	1.20	4.04	70.52
4.00	0.50	1.68	72.21
4.50	0.51	1.72	73.92
5.00	0.19	0.64	74.56
5.50	0.22	0.74	75.30
6.00	0.28	0.94	76.24
7.00	0.31	1.04	77.29
8.00	0.40	1.35	78.63
9.00	0.47	1.58	80.22
10.00	5.88	19.78	100.00
Totals	29.72	100.00	

Table G2: MACQUARIE UNIVERSITY CODES FOR SLIDES USED IN SEDIMENT PLANT OPAL CONTENT, ECOLOGY RESERVE SITES*

Sample #	Description	Location	Macquarie University #
E1	soil, 0-50mm	Ecol 1	MU 50591
E2	soil, 100-200mm		MU 50592
E3	soil, 0-50mm	Ecol 2	MU 50593
E4	soil, 400-500mm		MU 50594
E5	soil, 0-100mm	Ecol 3	MU 50595
E6	soil, 200-250mm		MU 50596
E7	soil, 500-600mm		MU 50597
E8	soil, 1000mm+		MU 50598

* For Table G3

SITE	SAMPLE #	Sand wt g	Sand %	Silt wt g	Silt %	Clay wt g	Clay %	Total wt g	Subsample #	Silt wt g	Opal wt g	Purity Prop*	Opal cc** wt (g)	Opal %	% Silt X % Opal
		PARTICLE SIZE DISTRIBUTION							OPAL CONTENT						
Site 1															
0-50mm	E1	17.563	66.246	3.744	14.121	5.205	19.633	26.512	1	0.381	0.038	0.810	0.031	8.145	0.012
100-200mm	E2	16.817	63.397	3.155	11.893	6.555	24.710	26.527	2	0.652	0.014				
Site 2															
0-50mm	E3	20.345	73.091	3.099	11.132	4.392	15.778	27.836	3	0.503	0.009	0.900	0.008	1.610	0.002
400-500mm	E4	14.571	66.968	3.071	14.113	4.117	18.919	21.759	4	0.445	0.004				
Site 3															
0-100mm	E5	38.864	90.351	2.005	4.661	2.146	4.988	43.014	5	0.431	0.009	0.770	0.007	1.662	0.001
200-250mm	E6	16.464	74.330	3.840	17.336	1.846	8.334	22.149	6	0.499	0.009	0.860	0.008	1.602	0.003
500-600mm	E7	27.255	62.375	6.762	15.475	9.679	22.150	43.695	7	0.659	0.023	0.890	0.021	3.122	0.005
1000mm+	E8	23.996	62.808	6.239	16.331	7.970	20.862	38.206	8	0.352	0.007	0.920	0.006	1.725	0.003

* Proportion
** corrected value (point counting)

Table G3: PARTICLE SIZE DISTRIBUTION AND OPAL CONTENT OF SAMPLES ECOLOGY RESERVE SITES

Table G4: MACQUARIE UNIVERSITY CODES FOR SLIDES USED IN SEDIMENT PLANT OPAL CONTENT, PILLIGA SITES*

Sample #	Description	Location	Macquarie University #
1	sheeting	Pilliga 8	MU 50599
2			MU 50600
3			MU 50601
4	A horizon		MU 50602
5			MU 50603
6			MU 50604
D1	Dome		MU 50605
B1	B horizon		MU 50606
F1	Faunal		MU 50607
2/1	pinch	Pilliga 2	MU 50608
2/2			MU 50609
6/1	pinch	Pilliga 6	MU 50610
6/2			MU 50611

* For Table G5

SITE	SAMPLE #	PARTICLE SIZE DISTRIBUTION Sand wt g	Sand %	Silt wt g	Silt %	Clay wt g	Clay %	Total wt g	OPAL CONTENT Subsample #	Silt wt g	Opal wt g	Purity Prop*	Opal cc** wt (g)	Opal %	% Silt X % Opal
SITE 8															
SHEETING	1	11.851	61.673	2.419	12.589	4.946	25.738	19.215	1	0.394	0.043	0.750	0.032	8.115	0.010
	2	10.499	57.837	2.316	12.760	5.337	29.403	18.153	2	0.356	0.047	0.680	0.032	8.895	0.011
	3	13.544	61.931	1.967	8.995	6.358	29.074	21.869	3	0.598	0.072	0.500	0.036	6.056	0.005
	Average		60.480		11.448		28.072						0.033	7.688	0.009
SITE 8															
A HORIZON	4	10.652	66.460	1.528	9.534	3.848	24.006	16.027	4	0.699	0.035	0.690	0.024	3.414	0.003
	5	16.377	65.018	2.985	11.852	5.826	23.130	25.189	5	0.626	0.053	0.750	0.039	6.288	0.007
	6	11.314	65.253	1.861	10.734	4.164	24.013	17.339	6	0.660	0.064	0.740	0.048	7.201	0.008
	Average		65.577		10.707		23.717						0.037	5.635	0.006
SITE 8															
DOME		12.409	71.069	1.991	11.401	3.061	17.529	17.460	D1	0.528	0.016	0.680	0.011	2.098	0.002
SITE 8															
B HORIZON		12.270	53.832	1.532	6.721	8.991	39.447	22.792	B1	0.515	0.019	0.680	0.013	2.508	0.001
SITE 8															
FAUNAL		1.366	33.117	0.240	5.820	2.518	61.064	4.124	F1	0.207	0.038	0.820	0.031	14.996	0.009
SITE 2															
	2/1	8.398	68.240	1.368	11.113	2.541	20.646	12.306	2/1	0.580	0.036	0.590	0.021	3.633	0.004
	2/2	9.025	57.615	1.595	10.184	5.044	32.201	15.664	2/2	0.594	0.030				
	Average		62.928		10.649		26.424								
SITE 6															
	6/1	10.169	72.763	1.428	10.218	2.378	17.019	13.975	6/1	0.580	0.065	0.610	0.040	6.829	0.007
	6/2	8.104	66.988	0.840	6.941	3.154	26.071	12.098	6/2	0.455	0.032				
	Average		69.875		8.580		21.545								

* Proportion
** corrected value (point counting)

Table G5: PARTICLE SIZE DISTRIBUTION AND OPAL CONTENT OF SAMPLES PILLIGA SITES

Table G6: MACQUARIE UNIVERSITY CODES FOR SLIDES USED IN SCANNING, PILLIGA PINCH SAMPLES*

Sample #	Description	Location	Macquarie University #
2/1	pinch	Pilliga 2	MU 50608
6/1	pinch	Pilliga 6	MU 50610
7a2	pinch	Pilliga 7	MU 50612
7b2	pinch	Pilliga 7	MU 50613
8a2	pinch	Pilliga 8	MU 50614
9a1	pinch	Pilliga 9	MU 50615
12a1	pinch	Pilliga 12	MU 50616

* For Tables G7 and G8

Morphological Type		Morph #	Total 7a2	% 7a2	% Cum	Total 7b2	% 7b2	% Cum	Total 9a1	% 9a1	% Cum	Total 8a2	% 8a2	% Cum	Total 12a1	% 12a1	% Cum	Total 2/1	% 2/1	% Cum	Total 6/1	% 6/1	% Cum
Lobates	bilobates	1	8.0	3.8	3.8	8.0	3.3	3.3	20.0	9.7	9.7	19.0	9.1	9.1	19.0	9.8	9.8	13.0	7.5	7.5	7.0	3.3	3.3
	polylobates	2	0.0	0.0	3.8	1.0	0.4	3.7	0.0	0.0	9.7	1.0	0.5	9.6	4.0	2.1	11.9	0.0	0.0	7.5	0.0	0.0	3.3
	crosses	3	0.0	0.0	3.8	0.0	0.0	3.7	0.0	0.0	9.7	2.0	1.0	10.6	7.0	3.6	15.5	0.0	0.0	7.5	0.0	0.0	3.3
Saddles		4	3.0	1.4	5.2	5.0	2.0	5.7	5.0	2.4	12.1	6.0	2.9	13.5	3.0	1.6	17.1	0.0	0.0	7.5	4.0	1.9	5.1
Dble Outlines		5	8.0	3.8	9.0	4.0	1.6	7.3	10.0	4.8	16.9	22.0	10.6	24.0	6.0	3.1	20.2	6.0	3.5	11.0	1.0	0.5	5.6
Cones		6	6.0	2.8	11.8	3.0	1.2	8.5	13.0	6.3	23.2	8.0	3.8	27.9	6.0	3.1	23.3	3.0	1.7	12.7	7.0	3.3	8.9
Rods: thick	smooth	7	12.0	5.7	17.5	18.0	7.3	15.9	7.0	3.4	26.6	16.0	7.7	35.6	36.0	18.7	42.0	9.0	5.2	17.9	7.0	3.3	12.1
	spiked	8	4.0	1.9	19.4	14.0	5.7	21.5	8.0	3.9	30.4	0.0	0.0	35.6	0.0	0.0	42.0	2.0	1.2	19.1	5.0	2.3	14.5
	jigsaw	9	7.0	3.3	22.7	4.0	1.6	23.2	0.0	0.0	30.4	1.0	0.5	36.1	0.0	0.0	42.0	3.0	1.7	20.8	4.0	1.9	16.4
	ridged	10	1.0	0.5	23.2	2.0	0.8	24.0	2.0	1.0	31.4	1.0	0.5	36.5	1.0	0.5	42.5	2.0	1.2	22.0	5.0	2.3	18.7
	rough	11	20.0	9.5	32.7	27.0	11.0	35.0	13.0	6.3	37.7	10.0	4.8	41.3	9.0	4.7	47.2	26.0	15.0	37.0	37.0	17.3	36.0
Rods: thin	smooth	12	2.0	0.9	33.6	2.0	0.8	35.8	3.0	1.4	39.1	7.0	3.4	44.7	2.0	1.0	48.2	3.0	1.7	38.7	0.0	0.0	36.0
	spiked	13	0.0	0.0	33.6	0.0	0.0	35.8	1.0	0.5	39.6	2.0	1.0	45.7	0.0	0.0	48.2	1.0	0.6	39.3	1.0	0.5	36.4
	jigsaw	14	0.0	0.0	33.6	0.0	0.0	35.8	0.0	0.0	39.6	1.0	0.5	46.2	0.0	0.0	48.2	0.0	0.0	39.3	0.0	0.0	36.4
	ridged	15	0.0	0.0	33.6	0.0	0.0	35.8	0.0	0.0	39.6	1.0	0.5	46.6	0.0	0.0	48.2	0.0	0.0	39.3	0.0	0.0	36.4
	rough	16	4.0	1.9	35.5	3.0	1.2	37.0	1.0	0.5	40.1	2.0	1.0	47.6	0.0	0.0	48.2	0.0	0.0	39.3	1.0	0.5	36.9
Rods: platey	jigsaw	17	0.0	0.0	35.5	0.0	0.0	37.0	1.0	0.5	40.6	0.0	0.0	47.6	0.0	0.0	48.2	0.0	0.0	39.3	0.0	0.0	36.9
	sinuous	18	0.0	0.0	35.5	0.0	0.0	37.0	1.0	0.5	41.1	0.0	0.0	47.6	0.0	0.0	48.2	1.0	0.6	39.9	1.0	0.5	37.4
Sheets 2D reg	honeycomb	19	1.0	0.5	36.0	0.0	0.0	37.0	0.0	0.0	41.1	0.0	0.0	47.6	1.0	0.5	48.7	0.0	0.0	39.9	0.0	0.0	37.4
	plain	20	5.0	2.4	38.4	1.0	0.4	37.4	0.0	0.0	41.1	2.0	1.0	48.6	0.0	0.0	48.7	0.0	0.0	39.9	0.0	0.0	37.4
	perforated	21	2.0	0.9	39.3	5.0	2.0	39.4	2.0	1.0	42.0	0.0	0.0	48.6	2.0	1.0	49.7	0.0	0.0	39.9	3.0	1.4	38.8
	bulbous	22	0.0	0.0	39.3	0.0	0.0	39.4	1.0	0.5	42.5	0.0	0.0	48.6	0.0	0.0	49.7	0.0	0.0	39.9	3.0	1.4	40.2
Sheets 3D reg	smooth	23	0.0	0.0	39.3	13.0	5.3	44.7	3.0	1.4	44.0	4.0	1.9	50.5	16.0	8.3	58.0	3.0	1.7	41.6	19.0	8.9	49.1
	rough	24	17.0	8.1	47.4	30.0	12.2	56.9	2.0	1.0	44.9	1.0	0.5	51.0	1.0	0.5	58.5	13.0	7.5	49.1	18.0	8.4	57.5
	honeycomb	25	0.0	0.0	47.4	2.0	0.8	57.7	0.0	0.0	44.9	0.0	0.0	51.0	0.0	0.0	58.5	0.0	0.0	49.1	0.0	0.0	57.5
	verrucose	26	7.0	3.3	50.7	2.0	0.8	58.5	1.0	0.5	45.4	0.0	0.0	51.0	0.0	0.0	58.5	0.0	0.0	49.1	1.0	0.5	57.9
Hairs & Prickles	long	27	30.0	14.2	64.9	34.0	13.8	72.4	21.0	10.1	55.6	15.0	7.2	58.2	11.0	5.7	64.2	45.0	26.0	75.1	42.0	19.6	77.6
	short	28	1.0	0.5	65.4	2.0	0.8	73.2	5.0	2.4	58.0	0.0	0.0	58.2	2.0	1.0	65.3	6.0	3.5	78.6	1.0	0.5	78.0
	gourds	29	18.0	8.5	73.9	12.0	4.9	78.0	17.0	8.2	66.2	12.0	5.8	63.9	7.0	3.6	68.9	7.0	4.0	82.7	6.0	2.8	80.8
Spheres: single	smooth	30	10.0	4.7	78.7	7.0	2.8	80.9	6.0	2.9	69.1	8.0	3.8	67.8	18.0	9.3	78.2	4.0	2.3	85.0	7.0	3.3	84.1
	spiked	31	0.0	0.0	78.7	1.0	0.4	81.3	1.0	0.5	69.6	0.0	0.0	67.8	0.0	0.0	78.2	0.0	0.0	85.0	3.0	1.4	85.5
	rough	32	35.0	16.6	95.3	34.0	13.8	95.1	51.0	24.6	94.2	34.0	16.3	84.1	9.0	4.7	82.9	20.0	11.6	96.5	22.0	10.3	95.8
	indented	33	0.0	0.0	95.3	1.0	0.4	95.5	0.0	0.0	94.2	0.0	0.0	84.1	2.0	1.0	83.9	2.0	1.2	97.7	0.0	0.0	95.8
	verrucose	34	5.0	2.4	97.6	3.0	1.2	96.7	2.0	1.0	95.2	0.0	0.0	84.1	0.0	0.0	83.9	0.0	0.0	97.7	0.0	0.0	95.8
Spheres: compound	smooth	35	1.0	0.5	98.1	0.0	0.0	96.7	0.0	0.0	95.2	0.0	0.0	84.1	0.0	0.0	83.9	1.0	0.6	98.3	2.0	0.9	96.7
	spiked	36	0.0	0.0	98.1	0.0	0.0	96.7	0.0	0.0	95.2	0.0	0.0	84.1	0.0	0.0	83.9	0.0	0.0	98.3	0.0	0.0	96.7
	rough	37	4.0	1.9	100.0	8.0	3.3	100.0	10.0	4.8	100.0	33.0	15.9	100.0	31.0	16.1	100.0	3.0	1.7	100.0	7.0	3.3	100.0
	indented	38	0.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0	100.0
		Total	211.0			246.0			207.0			208.0			193.0			173.0			214.0		

OTHERS		Total 7a2	% WHOLE SAMPLE	Total 7b2	% WHOLE SAMPLE	Total 9a1	% WHOLE SAMPLE	Total 8a2	% WHOLE SAMPLE	Total 12a1	% WHOLE SAMPLE	Total 2/1	% WHOLE SAMPLE	Total 6/1	% WHOLE SAMPLE
Sheets 2D nonreg		14.0	5.1	33.0	9.8	29.0	9.8	15.0	5.5	13.0	5.5	133.0	38.7	96.0	29.1
Sheets 3D nonreg	smooth	2.0	0.7	9.0	2.7	5.0	1.7	0.0	0.0	4.0	1.7	3.0	0.9	5.0	1.5
	rough	25.0	9.1	23.0	6.8	15.0	5.1	0.0	0.0	0.0	0.0	22.0	6.4	7.0	2.1
Unclassified silica		4.0	1.5	8.0	2.4	9.0	3.0	7.0	2.6	1.0	0.4	4.0	1.2	3.0	0.9
Other silica		18.0	6.6	19.0	5.6	31.0	10.5	43.0	15.8	24.0	10.2	9.0	2.6	5.0	1.5
	Total	63.0		92.0		89.0		65.0		42.0		171.0		116.0	

Table G7: SCANNING, PILLIGA PINCH SAMPLES
SAMPLES: 7a2, 7b2, 9a1, 8a2, 12a1, 2/1, 6/1.

Morph #	Total 7a2	Total 7b2	Total 9a1	Total 8a2	Total 12a1	Total 2/1	Total 6/1	Cum P 7a2	Cum P 7b2	Cum P 9a1	Cum P 8a2	Cum P 12a1	Cum P 2/1	Cum P 6/1	cf 7a2/7b2	cf 7a2/9a1	cf 7a2/2/1	cf 7a2/6/1	cf 9a1/2/1	cf 9a1/6/1	cf 2/1/6/1	cf 7a2/8a2	cf 7a2/12a1	cf 8a2/9a1	cf 8a2/12a1	cf 9a1/12a1
1	8.00	8.00	20.00	19.00	19.00	13.00	7.00	0.04	0.03	0.10	0.09	0.10	0.08	0.03	0.01	-0.06	-0.04	0.01	0.02	0.06	0.04	-0.05	-0.01	-0.01	-0.01	0.00
2	0.00	1.00	0.00	1.00	4.00	0.00	0.00	0.04	0.04	0.10	0.10	0.12	0.08	0.03	0.00	-0.06	-0.04	0.01	0.02	0.06	0.04	-0.06	-0.02	0.00	-0.02	-0.02
3	0.00	0.00	0.00	2.00	7.00	0.00	0.00	0.04	0.04	0.10	0.11	0.16	0.08	0.03	0.00	-0.06	-0.04	0.01	0.02	0.06	0.04	-0.07	-0.05	0.01	-0.05	-0.06
4	3.00	5.00	5.00	6.00	3.00	0.00	4.00	0.05	0.06	0.12	0.13	0.17	0.08	0.05	0.00	-0.07	-0.02	0.00	0.05	0.07	0.02	-0.08	-0.04	0.01	-0.04	-0.05
5	8.00	4.00	10.00	22.00	6.00	6.00	1.00	0.09	0.07	0.17	0.24	0.20	0.11	0.06	0.02	-0.08	-0.02	0.03	0.06	0.11	0.05	-0.15	0.04	0.07	0.04	-0.03
6	6.00	3.00	13.00	8.00	6.00	3.00	7.00	0.12	0.09	0.23	0.28	0.23	0.13	0.09	0.03	-0.11	-0.01	0.03	0.10	0.14	0.04	-0.16	0.05	0.05	0.05	0.00
7	12.00	18.00	7.00	16.00	36.00	9.00	7.00	0.18	0.16	0.27	0.36	0.42	0.18	0.12	0.02	-0.09	0.00	0.05	0.09	0.14	0.06	-0.18	-0.06	0.09	-0.06	-0.15
8	4.00	14.00	8.00	0.00	0.00	2.00	5.00	0.19	0.22	0.30	0.36	0.42	0.19	0.14	-0.02	-0.11	0.00	0.05	0.11	0.16	0.05	-0.16	-0.06	0.05	-0.06	-0.12
9	7.00	4.00	0.00	1.00	0.00	3.00	4.00	0.23	0.23	0.30	0.36	0.42	0.21	0.16	0.00	-0.08	0.02	0.06	0.10	0.14	0.04	-0.13	-0.06	0.06	-0.06	-0.12
10	1.00	2.00	2.00	1.00	1.00	2.00	5.00	0.23	0.24	0.31	0.37	0.42	0.22	0.19	-0.01	-0.08	0.01	0.05	0.09	0.13	0.03	-0.13	-0.06	0.05	-0.06	-0.11
11	20.00	27.00	13.00	10.00	9.00	26.00	37.00	0.33	0.35	0.38	0.41	0.47	0.37	0.36	-0.02	-0.05	-0.04	-0.03	0.01	0.02	0.01	-0.09	-0.06	0.04	-0.06	-0.09
12	2.00	2.00	3.00	7.00	2.00	3.00	0.00	0.34	0.36	0.39	0.45	0.48	0.39	0.36	-0.02	-0.05	-0.05	-0.02	0.00	0.03	0.03	-0.11	-0.03	0.06	-0.03	-0.09
13	0.00	0.00	1.00	2.00	0.00	1.00	1.00	0.34	0.36	0.40	0.46	0.48	0.39	0.36	-0.02	-0.06	-0.06	-0.03	0.00	0.03	0.03	-0.12	-0.03	0.06	-0.03	-0.09
14	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.34	0.36	0.40	0.46	0.48	0.39	0.36	-0.02	-0.06	-0.06	-0.03	0.00	0.03	0.03	-0.13	-0.02	0.07	-0.02	-0.09
15	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.34	0.36	0.40	0.47	0.48	0.39	0.36	-0.02	-0.06	-0.06	-0.03	0.00	0.03	0.03	-0.13	-0.02	0.07	-0.02	-0.09
16	4.00	3.00	1.00	2.00	0.00	0.00	1.00	0.36	0.37	0.40	0.48	0.48	0.39	0.37	-0.01	-0.05	-0.04	-0.01	0.01	0.03	0.02	-0.12	-0.01	0.07	-0.01	-0.08
17	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.36	0.37	0.41	0.48	0.48	0.39	0.37	-0.01	-0.05	-0.04	-0.01	0.01	0.04	0.02	-0.12	-0.01	0.07	-0.01	-0.08
18	0.00	0.00	1.00	0.00	0.00	1.00	1.00	0.36	0.37	0.41	0.48	0.48	0.40	0.37	-0.01	-0.06	-0.04	-0.02	0.01	0.04	0.03	-0.12	-0.01	0.07	-0.01	-0.07
19	1.00	0.00	0.00	0.00	1.00	0.00	0.00	0.36	0.37	0.41	0.48	0.49	0.40	0.37	-0.01	-0.05	-0.04	-0.01	0.01	0.04	0.03	-0.12	-0.01	0.07	-0.01	-0.08
20	5.00	1.00	0.00	2.00	0.00	0.00	0.00	0.38	0.37	0.41	0.49	0.49	0.40	0.37	0.01	-0.03	-0.01	0.01	0.01	0.04	0.03	-0.10	0.00	0.07	0.00	-0.08
21	2.00	5.00	2.00	0.00	2.00	0.00	3.00	0.39	0.39	0.42	0.49	0.50	0.40	0.39	0.00	-0.03	-0.01	0.01	0.02	0.03	0.01	-0.09	-0.01	0.07	-0.01	-0.08
22	0.00	0.00	1.00	0.00	0.00	0.00	3.00	0.39	0.39	0.43	0.49	0.50	0.40	0.40	0.00	-0.03	-0.01	-0.01	0.03	0.02	0.00	-0.09	-0.01	0.06	-0.01	-0.07
23	0.00	13.00	3.00	4.00	16.00	3.00	19.00	0.39	0.45	0.44	0.50	0.58	0.42	0.49	-0.05	-0.05	-0.02	-0.10	0.02	-0.05	-0.07	-0.11	-0.08	0.07	-0.08	-0.14
24	17.00	30.00	2.00	1.00	1.00	13.00	18.00	0.47	0.57	0.45	0.51	0.59	0.49	0.57	-0.10	0.02	-0.02	-0.10	-0.04	-0.13	-0.08	-0.04	-0.08	0.06	-0.08	-0.14
25	0.00	2.00	0.00	0.00	0.00	0.00	0.00	0.47	0.58	0.45	0.51	0.59	0.49	0.57	-0.10	0.02	-0.02	-0.10	-0.04	-0.13	-0.08	-0.04	-0.08	0.06	-0.08	-0.14
26	7.00	2.00	1.00	0.00	0.00	0.00	1.00	0.51	0.59	0.45	0.51	0.59	0.49	0.58	-0.08	0.05	0.02	-0.07	-0.04	-0.13	-0.09	0.00	-0.08	0.06	-0.08	-0.13
27	30.00	34.00	21.00	15.00	11.00	45.00	42.00	0.65	0.72	0.56	0.58	0.64	0.75	0.78	-0.07	0.09	-0.10	-0.13	-0.20	-0.22	-0.02	0.07	-0.06	0.03	-0.06	-0.09
28	1.00	2.00	5.00	0.00	2.00	6.00	1.00	0.65	0.73	0.58	0.58	0.65	0.79	0.78	-0.08	0.07	-0.13	-0.13	-0.21	-0.20	0.01	0.07	-0.07	0.00	-0.07	-0.07
29	18.00	12.00	17.00	12.00	7.00	7.00	6.00	0.74	0.78	0.66	0.64	0.69	0.83	0.81	-0.04	0.08	-0.09	-0.07	-0.16	-0.15	0.02	0.10	-0.05	-0.02	-0.05	-0.03
30	10.00	7.00	6.00	8.00	18.00	4.00	7.00	0.79	0.81	0.69	0.68	0.78	0.85	0.84	-0.02	0.10	-0.06	-0.05	-0.16	-0.15	0.01	0.11	-0.10	-0.01	-0.10	-0.09
31	0.00	1.00	1.00	0.00	0.00	0.00	3.00	0.79	0.81	0.70	0.68	0.78	0.85	0.86	-0.03	0.09	-0.06	-0.07	-0.15	-0.16	-0.01	0.11	-0.10	-0.02	-0.10	-0.09
32	35.00	34.00	51.00	34.00	9.00	20.00	22.00	0.95	0.95	0.94	0.84	0.83	0.97	0.96	0.00	0.01	-0.01	-0.01	-0.02	-0.02	0.01	0.11	0.01	-0.10	0.01	0.11
33	0.00	1.00	0.00	0.00	2.00	2.00	0.00	0.95	0.96	0.94	0.84	0.84	0.98	0.96	0.00	0.01	-0.02	-0.01	-0.03	-0.02	0.02	0.11	0.00	-0.10	0.00	0.10
34	5.00	3.00	2.00	0.00	0.00	0.00	0.00	0.98	0.97	0.95	0.84	0.84	0.98	0.96	0.01	0.02	0.00	0.02	-0.03	-0.01	0.02	0.13	0.00	-0.11	0.00	0.11
35	1.00	0.00	0.00	0.00	0.00	1.00	2.00	0.98	0.97	0.95	0.84	0.84	0.98	0.97	0.01	0.03	0.00	0.01	-0.03	-0.02	0.02	0.14	0.00	-0.11	0.00	0.11
36	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.98	0.97	0.95	0.84	0.84	0.98	0.97	0.01	0.03	0.00	0.01	-0.03	-0.02	0.02	0.14	0.00	-0.11	0.00	0.11
37	4.00	8.00	10.00	33.00	31.00	3.00	7.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
38	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	211.00	246.00	207.00	208.00	193.00	173.00	214.00																			

Table G8: PILLIGA PINCH SAMPLES; DATA FOR KOLMOGOROV-SMIRNOV TWO TAIL TEST

SAMPLES: 7a2, 7b2, 9a1, 8a2, 12a1, 2/1, 6/1.

Table G9: MACQUARIE UNIVERSITY CODES FOR SLIDES USED IN SCANNING, PILLIGA BULK LITTER SAMPLES*

Sample #	Description	Location	Macquarie University #
7a	Bulk Litter	Pilliga 7	MU 50584
8a	Bulk Litter	Pilliga 8	MU 50585
9b	Bulk Litter	Pilliga 9b	MU 50586
12b	Bulk Litter	Pilliga 12b	MU 50587

* For Tables G10 and G11

Morphological Type		Morph #	Total 7a	% 7a	% Cum	Total 8a	% 8a	% Cum	Total 9b	% 9b	% Cum	Total 12b	% 12b	% Cum
Lobates	bilobates	1	4.0	4.0	4.0	4.0	3.9	3.9	3.0	2.9	2.9	15.0	18.1	18.1
	polylobates	2	0.0	0.0	4.0	1.0	1.0	4.9	0.0	0.0	2.9	0.0	0.0	18.1
	crosses	3	0.0	0.0	4.0	0.0	0.0	4.9	0.0	0.0	2.9	1.0	1.2	19.3
Saddles		4	0.0	0.0	4.0	1.0	1.0	5.8	0.0	0.0	2.9	3.0	3.6	22.9
Dble Outlines		5	0.0	0.0	4.0	0.0	0.0	5.8	0.0	0.0	2.9	2.0	2.4	25.3
Cones		6	1.0	1.0	5.1	5.0	4.9	10.7	0.0	0.0	2.9	4.0	4.8	30.1
Rods: thick	smooth	7	7.0	7.1	12.1	10.0	9.7	20.4	2.0	1.9	4.8	3.0	3.6	33.7
	spiked	8	0.0	0.0	12.1	0.0	0.0	20.4	4.0	3.8	8.6	5.0	6.0	39.8
	jigsaw	9	0.0	0.0	12.1	0.0	0.0	20.4	1.0	1.0	9.5	1.0	1.2	41.0
	ridged	10	0.0	0.0	12.1	0.0	0.0	20.4	1.0	1.0	10.5	6.0	7.2	48.2
	rough	11	4.0	4.0	16.2	0.0	0.0	20.4	5.0	4.8	15.2	1.0	1.2	49.4
Rods: thin	smooth	12	1.0	1.0	17.2	5.0	4.9	25.2	0.0	0.0	15.2	3.0	3.6	53.0
	spiked	13	0.0	0.0	17.2	0.0	0.0	25.2	0.0	0.0	15.2	0.0	0.0	53.0
	jigsaw	14	0.0	0.0	17.2	0.0	0.0	25.2	0.0	0.0	15.2	0.0	0.0	53.0
	ridged	15	0.0	0.0	17.2	0.0	0.0	25.2	0.0	0.0	15.2	0.0	0.0	53.0
	rough	16	0.0	0.0	17.2	0.0	0.0	25.2	5.0	4.8	20.0	0.0	0.0	53.0
Rods: platey	jigsaw	17	2.0	2.0	19.2	1.0	1.0	26.2	0.0	0.0	20.0	6.0	7.2	60.2
	sinuous	18	1.0	1.0	20.2	0.0	0.0	26.2	3.0	2.9	22.9	1.0	1.2	61.4
Sheets 2D reg	honeycomb	19	0.0	0.0	20.2	0.0	0.0	26.2	0.0	0.0	22.9	0.0	0.0	61.4
	plain	20	0.0	0.0	20.2	0.0	0.0	26.2	0.0	0.0	22.9	1.0	1.2	62.7
	perforated	21	1.0	1.0	21.2	0.0	0.0	26.2	1.0	1.0	23.8	0.0	0.0	62.7
	bulbous	22	2.0	2.0	23.2	0.0	0.0	26.2	0.0	0.0	23.8	0.0	0.0	62.7
Sheets 3D reg	smooth	23	5.0	5.1	28.3	28.0	27.2	53.4	15.0	14.3	38.1	3.0	3.6	66.3
	rough	24	1.0	1.0	29.3	0.0	0.0	53.4	4.0	3.8	41.9	4.0	4.8	71.1
	honeycomb	25	0.0	0.0	29.3	0.0	0.0	53.4	0.0	0.0	41.9	0.0	0.0	71.1
	verrucose	26	0.0	0.0	29.3	0.0	0.0	53.4	0.0	0.0	41.9	0.0	0.0	71.1
Hairs & Prickles	long	27	45.0	45.5	74.7	25.0	24.3	77.7	39.0	37.1	79.0	22.0	26.5	97.6
	short	28	3.0	3.0	77.8	1.0	1.0	78.6	2.0	1.9	81.0	0.0	0.0	97.6
	gourds	29	4.0	4.0	81.8	0.0	0.0	78.6	2.0	1.9	82.9	1.0	1.2	98.8
Spheres: single	smooth	30	6.0	6.1	87.9	2.0	1.9	80.6	5.0	4.8	87.6	0.0	0.0	98.8
	spiked	31	0.0	0.0	87.9	0.0	0.0	80.6	0.0	0.0	87.6	0.0	0.0	98.8
	rough	32	7.0	7.1	94.9	1.0	1.0	81.6	8.0	7.6	95.2	0.0	0.0	98.8
	indented	33	0.0	0.0	94.9	0.0	0.0	81.6	0.0	0.0	95.2	0.0	0.0	98.8
	verrucose	34	0.0	0.0	94.9	0.0	0.0	81.6	1.0	1.0	96.2	1.0	1.2	100.0
Spheres: compound	smooth	35	4.0	4.0	99.0	16.0	15.5	97.1	3.0	2.9	99.0	0.0	0.0	100.0
	spiked	36	0.0	0.0	99.0	0.0	0.0	97.1	0.0	0.0	99.0	0.0	0.0	100.0
	rough	37	1.0	1.0	100.0	3.0	2.9	100.0	1.0	1.0	100.0	0.0	0.0	100.0
	indented	38	0.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0	100.0
		Total	99.0			103.0			105.0			83.0		

OTHERS			% WHOLE SAMPLE		% WHOLE SAMPLE		% WHOLE SAMPLE		% WHOLE SAMPLE
Sheets 2D nonreg		73.0	38.6	126.0	52.9	160.0	58.8	170.0	63.7
Sheets 3D nonreg	smooth	8.0	4.2	5.0	2.1	2.0	0.7	11.0	4.1
	rough	4.0	2.1	0.0	0.0	2.0	0.7	0.0	0.0
Unclassified silica		3.0	1.6	2.0	0.8	1.0	0.4	2.0	0.7
Other silica		2.0	1.1	2.0	0.8	2.0	0.7	1.0	0.4
	Total	90.0		135.0		167.0		184.0	

Table G10: SCANNING, PILLIGA BULK LITTER SAMPLES
SAMPLES 7a, 8a, 9b, 12b.

Morph #	Total 7a	Total 8a	Total 9b	Total 12b	Cum P 7a	Cum P 8a	Cum P 9b	Cum P 12b	cf 7a/8a	cf 7a/9b	cf 7a/12b	cf 8a/9b	cf 9b/12b	cf 8a/12b
1	4.00	4.00	3.00	15.00	0.04	0.04	0.03	0.18	0.00	0.01	-0.14	0.01	-0.15	-0.14
2	0.00	1.00	0.00	0.00	0.04	0.05	0.03	0.18	-0.01	0.01	-0.14	0.02	-0.15	-0.13
3	0.00	0.00	0.00	1.00	0.04	0.05	0.03	0.19	-0.01	0.01	-0.15	0.02	-0.16	-0.14
4	0.00	1.00	0.00	3.00	0.04	0.06	0.03	0.22	-0.02	0.01	-0.18	0.03	-0.19	-0.16
5	0.00	0.00	0.00	2.00	0.04	0.06	0.03	0.24	-0.02	0.01	-0.20	0.03	-0.21	-0.18
6	1.00	5.00	0.00	4.00	0.05	0.11	0.03	0.28	-0.06	0.02	-0.23	0.08	-0.25	-0.17
7	7.00	10.00	2.00	3.00	0.12	0.21	0.05	0.31	-0.09	0.07	-0.19	0.16	-0.26	-0.10
8	0.00	0.00	4.00	5.00	0.12	0.21	0.09	0.36	-0.09	0.03	-0.24	0.12	-0.27	-0.15
9	0.00	0.00	1.00	1.00	0.12	0.21	0.10	0.37	-0.09	0.02	-0.25	0.11	-0.27	-0.16
10	0.00	0.00	1.00	6.00	0.12	0.21	0.11	0.43	-0.09	0.01	-0.31	0.10	-0.32	-0.22
11	4.00	0.00	5.00	1.00	0.16	0.21	0.16	0.44	-0.05	0.00	-0.28	0.05	-0.28	-0.23
12	1.00	5.00	0.00	3.00	0.17	0.26	0.16	0.47	-0.09	0.01	-0.30	0.10	-0.31	-0.21
13	0.00	0.00	0.00	0.00	0.17	0.26	0.16	0.47	-0.09	0.01	-0.30	0.10	-0.31	-0.21
14	0.00	0.00	0.00	0.00	0.17	0.26	0.16	0.47	-0.09	0.01	-0.30	0.10	-0.31	-0.21
15	0.00	0.00	0.00	0.00	0.17	0.26	0.16	0.47	-0.09	0.01	-0.30	0.10	-0.31	-0.21
16	0.00	0.00	5.00	0.00	0.17	0.26	0.21	0.47	-0.09	-0.04	-0.30	0.05	-0.26	-0.21
17	2.00	1.00	0.00	6.00	0.19	0.27	0.21	0.53	-0.08	-0.02	-0.34	0.06	-0.32	-0.26
18	1.00	0.00	3.00	1.00	0.20	0.27	0.24	0.54	-0.07	-0.04	-0.34	0.03	-0.30	-0.27
19	0.00	0.00	0.00	0.00	0.20	0.27	0.24	0.54	-0.07	-0.04	-0.34	0.03	-0.30	-0.27
20	0.00	0.00	0.00	1.00	0.20	0.27	0.24	0.55	-0.07	-0.04	-0.35	0.03	-0.31	-0.28
21	1.00	0.00	1.00	0.00	0.21	0.27	0.25	0.55	-0.06	-0.04	-0.34	0.02	-0.30	-0.28
22	2.00	0.00	0.00	0.00	0.23	0.27	0.25	0.55	-0.04	-0.02	-0.32	0.02	-0.30	-0.28
23	5.00	28.00	15.00	3.00	0.28	0.55	0.40	0.58	-0.27	-0.12	-0.30	0.15	-0.18	-0.03
24	1.00	0.00	4.00	4.00	0.29	0.55	0.44	0.63	-0.26	-0.15	-0.33	0.11	-0.18	-0.07
25	0.00	0.00	0.00	0.00	0.29	0.55	0.44	0.63	-0.26	-0.15	-0.33	0.11	-0.18	-0.07
26	0.00	0.00	0.00	0.00	0.29	0.55	0.44	0.63	-0.26	-0.15	-0.33	0.11	-0.18	-0.07
27	45.00	25.00	39.00	22.00	0.75	0.81	0.84	0.85	-0.06	-0.09	-0.10	-0.03	-0.01	-0.04
28	3.00	1.00	2.00	0.00	0.78	0.82	0.86	0.85	-0.04	-0.08	-0.07	-0.04	0.01	-0.03
29	4.00	0.00	2.00	1.00	0.82	0.82	0.88	0.86	0.00	-0.06	-0.04	-0.06	0.02	-0.04
30	6.00	2.00	5.00	0.00	0.88	0.84	0.93	0.86	0.04	-0.05	0.02	-0.09	0.07	-0.02
31	0.00	0.00	0.00	0.00	0.88	0.84	0.93	0.86	0.04	-0.05	0.02	-0.09	0.07	-0.02
32	7.00	1.00	8.00	0.00	0.95	0.85	1.01	0.86	0.10	-0.06	0.09	-0.16	0.15	-0.01
33	0.00	0.00	0.00	0.00	0.95	0.85	1.01	0.86	0.10	-0.06	0.09	-0.16	0.15	-0.01
34	0.00	0.00	1.00	1.00	0.95	0.85	1.02	0.87	0.10	-0.07	0.08	-0.17	0.15	-0.02
35	4.00	16.00	3.00	0.00	0.99	1.01	1.05	0.87	-0.02	-0.06	0.12	-0.04	0.18	0.14
36	0.00	0.00	0.00	0.00	0.99	1.01	1.05	0.87	-0.02	-0.06	0.12	-0.04	0.18	0.14
37	1.00	3.00	1.00	0.00	1.00	1.04	1.06	0.87	-0.04	-0.06	0.13	-0.02	0.19	0.17
38	0.00	0.00	0.00	0.00	1.00	1.04	1.06	0.87	-0.04	-0.06	0.13	-0.02	0.19	0.17
Total	99.00	103.00	105.00	83.00										

Table G11: PILLIGA BULK LITTER SAMPLES; DATA FOR KOLMOGOROV-SMIRNOV TWO TAIL TEST

SAMPLES 7a, 8a, 9b, 12b.

Table G12: SCANNING, PILLIGA ACACIA SPECIES

MORPHOLOGICAL TYPE		MORPH #	A. lineata (MU 50542) Total	%	% Cum	A. tindaleae (MU 50536) Total	%	% Cum	A. triptera (MU 50543) Total	%	% Cum
RODS: THICK	smooth	1	1.0	0.5	0.5	1.0	0.5	0.5	9.0	4.5	4.5
	spiked	2	0.0	0.0	0.5	2.0	1.0	1.5	11.0	5.5	10.0
	jigsawed	3	0.0	0.0	0.5	0.0	0.0	1.5	0.0	0.0	10.0
	ridged	4	3.0	1.5	2.0	6.0	3.0	4.5	25.0	12.5	22.5
	rough	5	2.0	1.0	3.0	2.0	1.0	5.5	0.0	0.0	22.5
RODS: THIN	smooth	6	1.0	0.5	3.5	0.0	0.0	5.5	1.0	0.5	23.0
	spiked	7	0.0	0.0	3.5	1.0	0.5	6.0	1.0	0.5	23.5
	jigsawed	8	0.0	0.0	3.5	0.0	0.0	6.0	0.0	0.0	23.5
	ridged	9	0.0	0.0	3.5	7.0	3.5	9.5	0.0	0.0	23.5
	rough	10	0.0	0.0	3.5	0.0	0.0	9.5	0.0	0.0	23.5
SHEETS: 2D	honeycomb	11	2.0	1.0	4.5	5.0	2.5	12.0	3.0	1.5	25.0
	plain	12	130.0	65.0	69.5	72.0	36.0	48.0	80.0	40.0	65.0
	bulbous	13	3.0	1.5	71.0	0.0	0.0	48.0	1.0	0.5	65.5
SHEETS: 3D, REGULAR	smooth	14	1.0	0.5	71.5	0.0	0.0	48.0	2.0	1.0	66.5
	rough	15	1.0	0.5	72.0	1.0	0.5	48.5	0.0	0.0	66.5
	honeycomb	16	0.0	0.0	72.0	1.0	0.5	49.0	0.0	0.0	66.5
SHEETS: 3D, IRREG	smooth	17	28.0	14.0	86.0	44.0	22.0	71.0	13.0	6.5	73.0
	rough	18	12.0	6.0	92.0	0.0	0.0	71.0	0.0	0.0	73.0
	honeycomb	19	1.0	0.5	92.5	0.0	0.0	71.0	0.0	0.0	73.0
	ridged	20	0.0	0.0	92.5	45.0	22.5	93.5	35.0	17.5	90.5
HAIRS & PRICKLES	long	21	4.0	2.0	94.5	7.0	3.5	97.0	13.0	6.5	97.0
	short	22	5.0	2.5	97.0	2.0	1.0	98.0	2.0	1.0	98.0
	gourd	23	1.0	0.5	97.5	0.0	0.0	98.0	0.0	0.0	98.0
SPHERES	all	24	5.0	2.5	100.0	4.0	2.0	100.0	2.0	1.0	99.0
UNCLASS		25	0.0	0.0	100.0	0.0	0.0	100.0	2.0	1.0	100.0
	TOTAL		200.0	100.0		200.0	100.0		200.0	100.0	

Table G13: PILLIGA ACACIA SPECIES: DATA FOR KOLMOGOROV-SMIRNOV TWO TAIL TEST

MORPHOLOGICAL TYPE		MORPH #	Total lineata	Total tindaleae	Total triptera	P lineata	P tindaleae	P triptera	cf lin/tin	cf lin/tri	cf tin/tri
RODS: THICK	smooth	1	1.00	1.00	9.00	0.01	0.01	0.05	0.00	-0.04	-0.04
	spiked	2	0.00	2.00	11.00	0.00	0.01	0.06	-0.01	-0.06	-0.05
	jigsawed	3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	ridged	4	3.00	6.00	25.00	0.02	0.03	0.13	-0.02	-0.11	-0.10
	rough	5	2.00	2.00	0.00	0.01	0.01	0.00	0.00	0.01	0.01
RODS: THIN	smooth	6	1.00	0.00	1.00	0.01	0.00	0.01	0.01	0.00	-0.01
	spiked	7	0.00	1.00	1.00	0.00	0.01	0.01	-0.01	-0.01	0.00
	jigsawed	8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	ridged	9	0.00	7.00	0.00	0.00	0.04	0.00	-0.04	0.00	0.04
	rough	10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SHEETS: 2D	honeycomb	11	2.00	5.00	3.00	0.01	0.03	0.02	-0.02	-0.01	0.01
	plain	12	130.00	72.00	80.00	0.65	0.36	0.40	0.29	0.25	-0.04
	bulbous	13	3.00	0.00	1.00	0.02	0.00	0.01	0.02	0.01	-0.01
SHEETS: 3D, REGULAR	smooth	14	1.00	0.00	2.00	0.01	0.00	0.01	0.01	-0.01	-0.01
	rough	15	1.00	1.00	0.00	0.01	0.01	0.00	0.00	0.01	0.01
	honeycomb	16	0.00	1.00	0.00	0.00	0.01	0.00	-0.01	0.00	0.01
SHEETS: 3D, IRREG	smooth	17	28.00	44.00	13.00	0.14	0.22	0.07	-0.08	0.08	0.16
	rough	18	12.00	0.00	0.00	0.06	0.00	0.00	0.06	0.06	0.00
	honeycomb	19	1.00	0.00	0.00	0.01	0.00	0.00	0.01	0.01	0.00
	ridged	20	0.00	45.00	35.00	0.00	0.23	0.18	-0.23	-0.18	0.05
HAIRS & PRICKLES	long	21	4.00	7.00	13.00	0.02	0.04	0.07	-0.02	-0.05	-0.03
	short	22	5.00	2.00	2.00	0.03	0.01	0.01	0.02	0.02	0.00
	gourd	23	1.00	0.00	0.00	0.01	0.00	0.00	0.01	0.01	0.00
SPHERES	all	24	5.00	4.00	2.00	0.03	0.02	0.01	0.01	0.02	0.01
UNCLASS		25	0.00	0.00	2.00	0.00	0.00	0.01	0.00	-0.01	-0.01
	TOTAL		200.00	200.00	200.00						

Table G14: PILLIGA PINCH AND LITTER SAMPLES; DATA FOR KOLMOGOROV-SMIRNOV TWO TAIL TEST
SITES 7, 8, 9, 12.

Morph #	Cum P 7a2 soil	Cum P 7b2 soil	Cum P 9a1 soil	Cum P 8a2 soil	Cum P 12a1 soil	Cum P 7a litter	Cum P 8a litter	Cum P 9b litter	Cum P 12b litter	cf 7a lit 7a2 soil	cf 7a lit 7b2 soil	cf 8a lit 8a2 soil	cf 9b lit 9a1 soil	cf 12b lit 12a1 soil
1	0.04	0.03	0.10	0.09	0.10	0.04	0.04	0.03	0.18	0.00	0.01	-0.05	-0.07	0.08
2	0.04	0.04	0.10	0.10	0.12	0.04	0.05	0.03	0.18	0.00	0.00	0.00	0.00	-0.02
3	0.04	0.04	0.10	0.11	0.16	0.04	0.05	0.03	0.19	0.00	0.00	-0.01	0.00	-0.02
4	0.05	0.06	0.12	0.13	0.17	0.04	0.06	0.03	0.23	-0.01	-0.02	-0.02	-0.02	0.02
5	0.09	0.07	0.17	0.24	0.20	0.04	0.06	0.03	0.25	-0.04	-0.02	-0.11	-0.05	-0.01
6	0.12	0.09	0.23	0.28	0.23	0.05	0.11	0.03	0.30	-0.02	0.00	0.01	-0.06	0.02
7	0.18	0.16	0.27	0.36	0.42	0.12	0.20	0.05	0.34	0.01	0.00	0.02	-0.01	-0.15
8	0.19	0.22	0.30	0.36	0.42	0.12	0.20	0.09	0.40	-0.02	-0.06	0.00	0.00	0.06
9	0.23	0.23	0.30	0.36	0.42	0.12	0.20	0.10	0.41	-0.03	-0.02	0.00	0.01	0.01
10	0.23	0.24	0.31	0.37	0.42	0.12	0.20	0.10	0.48	0.00	-0.01	0.00	0.00	0.07
11	0.33	0.35	0.38	0.41	0.47	0.16	0.20	0.15	0.49	-0.05	-0.07	-0.05	-0.02	-0.03
12	0.34	0.36	0.39	0.45	0.48	0.17	0.25	0.15	0.53	0.00	0.00	0.01	-0.01	0.03
13	0.34	0.36	0.40	0.46	0.48	0.17	0.25	0.15	0.53	0.00	0.00	-0.01	0.00	0.00
14	0.34	0.36	0.40	0.46	0.48	0.17	0.25	0.15	0.53	0.00	0.00	0.00	0.00	0.00
15	0.34	0.36	0.40	0.47	0.48	0.17	0.25	0.15	0.53	0.00	0.00	0.00	0.00	0.00
16	0.36	0.37	0.40	0.48	0.48	0.17	0.25	0.20	0.53	-0.02	-0.01	-0.01	0.04	0.00
17	0.36	0.37	0.41	0.48	0.48	0.19	0.26	0.20	0.60	0.02	0.02	0.01	0.00	0.07
18	0.36	0.37	0.41	0.48	0.48	0.20	0.26	0.23	0.61	0.01	0.01	0.00	0.02	0.01
19	0.36	0.37	0.41	0.48	0.49	0.20	0.26	0.23	0.61	0.00	0.00	0.00	0.00	-0.01
20	0.38	0.37	0.41	0.49	0.49	0.20	0.26	0.23	0.63	-0.02	0.00	-0.01	0.00	0.01
21	0.39	0.39	0.42	0.49	0.50	0.21	0.26	0.24	0.63	0.00	-0.01	0.00	0.00	-0.01
22	0.39	0.39	0.43	0.49	0.50	0.23	0.26	0.24	0.63	0.02	0.02	0.00	0.00	0.00
23	0.39	0.45	0.44	0.50	0.58	0.28	0.53	0.38	0.66	0.05	0.00	0.25	0.13	-0.05
24	0.47	0.57	0.45	0.51	0.59	0.29	0.53	0.42	0.71	-0.07	-0.11	0.00	0.03	0.04
25	0.47	0.58	0.45	0.51	0.59	0.29	0.53	0.42	0.71	0.00	-0.01	0.00	0.00	0.00
26	0.51	0.59	0.45	0.51	0.59	0.29	0.53	0.42	0.71	-0.03	-0.01	0.00	0.00	0.00
27	0.65	0.72	0.56	0.58	0.64	0.75	0.78	0.79	0.98	0.31	0.32	0.17	0.27	0.21
28	0.65	0.73	0.58	0.58	0.65	0.78	0.79	0.81	0.98	0.03	0.02	0.01	-0.01	-0.01
29	0.74	0.78	0.66	0.64	0.69	0.82	0.79	0.83	0.99	-0.04	-0.01	-0.06	-0.06	-0.02
30	0.79	0.81	0.69	0.68	0.78	0.88	0.81	0.88	0.99	0.01	0.03	-0.02	0.02	-0.09
31	0.79	0.81	0.70	0.68	0.78	0.88	0.81	0.88	0.99	0.00	0.00	0.00	0.00	0.00
32	0.95	0.95	0.94	0.84	0.83	0.95	0.82	0.95	0.99	-0.10	-0.07	-0.15	-0.17	-0.05
33	0.95	0.96	0.94	0.84	0.84	0.95	0.82	0.95	0.99	0.00	0.00	0.00	0.00	-0.01
34	0.98	0.97	0.95	0.84	0.84	0.95	0.82	0.96	1.00	-0.02	-0.01	0.00	0.00	0.01
35	0.98	0.97	0.95	0.84	0.84	0.99	0.97	0.99	1.00	0.04	0.04	0.16	0.03	0.00
36	0.98	0.97	0.95	0.84	0.84	0.99	0.97	0.99	1.00	0.00	0.00	0.00	0.00	0.00
37	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	-0.01	-0.02	-0.13	-0.04	-0.16
38	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00

Table G15: MACQUARIE UNIVERSITY CODES FOR SLIDES USED IN SCANNING, ECOLOGY RESERVE ASH, LITTER AND TOPSOIL SAMPLES*

Sample #	Description	Location	Macquarie University #
2a	Ash, Day 2	Ecol	MU 50617
5a	Ash, Day 14	Ecol	MU 50618
8a	Ash, Day 30	Ecol	MU 50619
3	Bulk Litter	Ecol 3	MU 50590
E1	soil, 0-50mm	Ecol 1	MU 50591
E3	soil, 0-50mm	Ecol 2	MU 50593
E5	soil, 0-100mm	Ecol 3	MU 50595

* For Tables G16 and G17

MORPHOLOGICAL TYPE		MORPH #	ASH, DAY 2 Total	%	% Cum	ASH, DAY 14 Total	%	% Cum	ASH, DAY 30 Total	%	% Cum	LITTER Total	%	% Cum	SOIL SITE 1 Total	%	% Cum	SOIL SITE 2 Total	%	% Cum	SOIL SITE 3 Total	%	% Cum
			sample 2a			sample 5a			sample 8a			sample 3			sample E1			sample E3			sample E5		
Lobates	bilobates	1	3.0	1.6	1.6	15.0	7.7	7.7	10.0	4.9	4.9	7.0	2.7	2.7	7.0	3.6	3.6	8.0	4.1	4.1	11.0	4.8	4.8
Saddles	polylobates	2	0.0	0.0	1.6	0.0	0.0	7.7	1.0	0.5	5.3	0.0	0.0	2.7	0.0	0.0	3.6	1.0	0.5	4.6	0.0	0.0	4.8
Dble Outlines	crosses	3	0.0	0.0	1.6	1.0	0.5	8.2	1.0	0.5	5.8	1.0	0.4	3.0	0.0	0.0	3.6	0.0	0.0	4.6	0.0	0.0	4.8
Saddles		4	2.0	1.1	2.7	0.0	0.0	8.2	1.0	0.5	6.3	0.0	0.0	3.0	0.0	0.0	3.6	0.0	0.0	4.6	4.0	1.7	6.5
Dble Outlines		5	2.0	1.1	3.8	6.0	3.1	11.2	3.0	1.5	7.8	0.0	0.0	3.0	0.0	0.0	3.6	2.0	1.0	5.6	5.0	2.2	8.7
Cones		6	2.0	1.1	4.9	2.0	1.0	12.2	2.0	1.0	8.7	3.0	1.1	4.2	3.0	1.5	5.1	0.0	0.0	5.6	1.0	0.4	9.1
Rods: thick	smooth	7	6.0	3.3	8.2	20.0	10.2	22.4	39.0	18.9	27.7	6.0	2.3	6.5	10.0	5.1	10.2	8.0	4.1	9.6	24.0	10.4	19.6
	spiked	8	2.0	1.1	9.2	12.0	6.1	28.6	12.0	5.8	33.5	9.0	3.4	9.9	6.0	3.0	13.2	7.0	3.6	13.2	4.0	1.7	21.3
	jigsaw	9	3.0	1.6	10.9	6.0	3.1	31.6	2.0	1.0	34.5	6.0	2.3	12.2	4.0	2.0	15.2	3.0	1.5	14.7	2.0	0.9	22.2
	ridged	10	5.0	2.7	13.6	3.0	1.5	33.2	13.0	6.3	40.8	9.0	3.4	15.6	9.0	4.6	19.8	5.0	2.5	17.3	3.0	1.3	23.5
	rough	11	13.0	7.1	20.7	26.0	13.3	46.4	28.0	13.6	54.4	9.0	3.4	19.0	50.0	25.4	45.2	42.0	21.3	38.6	46.0	20.0	43.5
Rods: thin	smooth	12	2.0	1.1	21.7	4.0	2.0	48.5	2.0	1.0	55.3	2.0	0.8	19.8	1.0	0.5	45.7	0.0	0.0	38.6	8.0	3.5	47.0
	spiked	13	2.0	1.1	22.8	0.0	0.0	48.5	0.0	0.0	55.3	0.0	0.0	19.8	0.0	0.0	45.7	0.0	0.0	38.6	1.0	0.4	47.4
	jigsaw	14	0.0	0.0	22.8	0.0	0.0	48.5	0.0	0.0	55.3	0.0	0.0	19.8	0.0	0.0	45.7	0.0	0.0	38.6	0.0	0.0	47.4
	ridged	15	0.0	0.0	22.8	0.0	0.0	48.5	1.0	0.5	55.8	0.0	0.0	19.8	0.0	0.0	45.7	0.0	0.0	38.6	0.0	0.0	47.4
	rough	16	1.0	0.5	23.4	4.0	2.0	50.5	2.0	1.0	56.8	1.0	0.4	20.2	6.0	3.0	48.7	2.0	1.0	39.6	4.0	1.7	49.1
Rods: platey	jigsaw	17	19.0	10.3	33.7	10.0	5.1	55.6	6.0	2.9	59.7	69.0	26.2	46.4	1.0	0.5	49.2	3.0	1.5	41.1	0.0	0.0	49.1
	sinuous	18	31.0	16.8	50.5	3.0	1.5	57.1	0.0	0.0	59.7	2.0	0.8	47.1	2.0	1.0	50.3	0.0	0.0	41.1	0.0	0.0	49.1
Sheets 2D reg	honeycomb	19	0.0	0.0	50.5	0.0	0.0	57.1	0.0	0.0	59.7	0.0	0.0	47.1	0.0	0.0	50.3	0.0	0.0	41.1	1.0	0.4	49.6
	plain	20	1.0	0.5	51.1	0.0	0.0	57.1	1.0	0.5	60.2	1.0	0.4	47.5	7.0	3.6	53.8	4.0	2.0	43.1	0.0	0.0	49.6
	perforated	21	1.0	0.5	51.6	0.0	0.0	57.1	0.0	0.0	60.2	3.0	1.1	48.7	2.0	1.0	54.8	0.0	0.0	43.1	0.0	0.0	49.6
	bulbous	22	52.0	28.3	79.9	20.0	10.2	67.3	19.0	9.2	69.4	32.0	12.2	60.8	15.0	7.6	62.4	10.0	5.1	48.2	11.0	4.8	54.3
Sheets 3D reg	smooth	23	4.0	2.2	82.1	5.0	2.6	69.9	7.0	3.4	72.8	4.0	1.5	62.4	7.0	3.6	66.0	10.0	5.1	53.3	17.0	7.4	61.7
	rough	24	3.0	1.6	83.7	6.0	3.1	73.0	7.0	3.4	76.2	8.0	3.0	65.4	36.0	18.3	84.3	50.0	25.4	78.7	22.0	9.6	71.3
	honeycomb	25	0.0	0.0	83.7	0.0	0.0	73.0	0.0	0.0	76.2	1.0	0.4	65.8	0.0	0.0	84.3	2.0	1.0	79.7	1.0	0.4	71.7
	verrucose	26	0.0	0.0	83.7	0.0	0.0	73.0	0.0	0.0	76.2	1.0	0.4	66.2	0.0	0.0	84.3	0.0	0.0	79.7	0.0	0.0	71.7
Hairs & Prickles	long	27	24.0	13.0	96.7	30.0	15.3	88.3	11.0	5.3	81.6	23.0	8.7	74.9	13.0	6.6	90.9	19.0	9.6	89.3	20.0	8.7	80.4
	short	28	0.0	0.0	96.7	4.0	2.0	90.3	9.0	4.4	85.9	2.0	0.8	75.7	1.0	0.5	91.4	3.0	1.5	90.9	0.0	0.0	80.4
	gourds	29	0.0	0.0	96.7	0.0	0.0	90.3	2.0	1.0	86.9	2.0	0.8	76.4	0.0	0.0	91.4	0.0	0.0	90.9	5.0	2.2	82.6
Spheres: single	smooth	30	1.0	0.5	97.3	1.0	0.5	90.8	4.0	1.9	88.8	7.0	2.7	79.1	1.0	0.5	91.9	4.0	2.0	92.9	3.0	1.3	83.9
	spiked	31	1.0	0.5	97.8	1.0	0.5	91.3	1.0	0.5	89.3	0.0	0.0	79.1	3.0	1.5	93.4	0.0	0.0	92.9	2.0	0.9	84.8
	rough	32	2.0	1.1	98.9	10.0	5.1	96.4	14.0	6.8	96.1	47.0	17.9	97.0	12.0	6.1	99.5	4.0	2.0	94.9	25.0	10.9	95.7
	indented	33	1.0	0.5	99.5	0.0	0.0	96.4	0.0	0.0	96.1	0.0	0.0	97.0	0.0	0.0	99.5	6.0	3.0	98.0	2.0	0.9	96.5
	verrucose	34	0.0	0.0	99.5	7.0	3.6	100.0	6.0	2.9	99.0	0.0	0.0	97.0	1.0	0.5	100.0	2.0	1.0	99.0	1.0	0.4	97.0
Spheres: compound	smooth	35	0.0	0.0	99.5	0.0	0.0	100.0	0.0	0.0	99.0	6.0	2.3	99.2	0.0	0.0	100.0	0.0	0.0	99.0	5.0	2.2	99.1
	spiked	36	0.0	0.0	99.5	0.0	0.0	100.0	0.0	0.0	99.0	0.0	0.0	99.2	0.0	0.0	100.0	0.0	0.0	99.0	0.0	0.0	99.1
	rough	37	1.0	0.5	100.0	0.0	0.0	100.0	2.0	1.0	100.0	2.0	0.8	100.0	0.0	0.0	100.0	2.0	1.0	100.0	2.0	0.9	100.0
	indented	38	0.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0	100.0
		Total	184.0			196.0			206.0			263.0			197.0			197.0			230.0		

OTHERS			% WHOLE SAMPLE		% WHOLE SAMPLE		% WHOLE SAMPLE		% WHOLE SAMPLE		% WHOLE SAMPLE		% WHOLE SAMPLE		% WHOLE SAMPLE
Sheets 2D nonreg		105.0	34.9	44.0	16.4	38.0	12.9	145.0	35.5	60.0	21.1	31.0	12.4	53.0	15.7
Sheets 3D nonreg	smooth	3.0	1.0	9.0	3.3	20.0	6.8	15.0	3.7	8.0	2.8	11.0	4.4	16.0	4.7
	rough	7.0	2.3	13.0	4.8	20.0	6.8	8.0	2.0	15.0	5.3	5.0	2.0	20.0	5.9
Unclassified silica		2.0	0.7	4.0	1.5	3.0	1.0	4.0	1.0	1.0	0.4	0.0	0.0	10.0	3.0
Other silica		0.0	0.0	3.0	1.1	8.0	2.7	5.0	1.2	4.0	1.4	6.0	2.4	9.0	2.7
	Total	117.0		73.0		89.0		177.0		88.0		53.0		108.0	

Table G16: SCANNING; ECOLOGY RESERVE, ASH, LITTER AND TOPSOIL

MORPH #	ASH DAY 2	ASH DAY 14	ASH DAY 30	TOTALS LITTER Litter	SOIL SITE 1	SOIL SITE 2	SOIL SITE 3	CUMULATIVE P							COMPARISONS													
	2a	5a	8a	3	E1	E3	E5	2a	5a	8a	3	E1	E3	E5	2a/5a	2a/8a	5a/8a	3/2a	3/5a	3/8a	E1/E3	E1/E5	E3/E5	3/E1	3/E3	3/E5
1	3.00	15.00	10.00	7.00	7.00	8.00	11.00	0.02	0.08	0.05	0.03	0.04	0.04	0.05	-0.06	-0.03	0.03	0.01	-0.05	-0.02	-0.01	-0.01	-0.01	-0.01	-0.01	-0.02
2	0.00	0.00	1.00	0.00	0.00	1.00	0.00	0.02	0.08	0.05	0.03	0.04	0.05	0.05	-0.06	-0.04	0.02	0.01	-0.05	-0.03	-0.01	-0.01	0.00	-0.01	-0.02	-0.02
3	0.00	1.00	1.00	1.00	0.00	0.00	0.00	0.02	0.08	0.06	0.03	0.04	0.05	0.05	-0.07	-0.04	0.02	0.01	-0.05	-0.03	-0.01	-0.01	0.00	-0.01	-0.02	-0.02
4	2.00	0.00	1.00	0.00	0.00	0.00	4.00	0.03	0.08	0.06	0.03	0.04	0.05	0.07	-0.05	-0.04	0.02	0.00	-0.05	-0.03	-0.01	-0.03	-0.02	-0.01	-0.02	-0.03
5	2.00	6.00	3.00	0.00	0.00	2.00	5.00	0.04	0.11	0.08	0.03	0.04	0.06	0.09	-0.07	-0.04	0.03	-0.01	-0.08	-0.05	-0.02	-0.05	-0.03	-0.01	-0.03	-0.06
6	2.00	2.00	2.00	3.00	3.00	0.00	1.00	0.05	0.12	0.09	0.04	0.05	0.06	0.09	-0.07	-0.04	0.04	-0.01	-0.08	-0.05	-0.01	-0.04	-0.04	-0.01	-0.01	-0.05
7	6.00	20.00	39.00	6.00	10.00	8.00	24.00	0.08	0.22	0.28	0.06	0.10	0.10	0.20	-0.14	-0.20	-0.05	-0.02	-0.16	-0.21	0.01	-0.09	-0.10	-0.04	-0.03	-0.13
8	2.00	12.00	12.00	9.00	6.00	7.00	4.00	0.09	0.29	0.33	0.10	0.13	0.13	0.21	-0.19	-0.24	-0.05	0.01	-0.19	-0.24	0.00	-0.08	-0.08	-0.03	-0.03	-0.11
9	3.00	6.00	2.00	6.00	4.00	3.00	2.00	0.11	0.32	0.34	0.12	0.15	0.15	0.22	-0.21	-0.24	-0.03	0.01	-0.19	-0.22	0.01	-0.07	-0.07	-0.03	-0.03	-0.10
10	5.00	3.00	13.00	9.00	9.00	5.00	3.00	0.14	0.33	0.41	0.16	0.20	0.17	0.23	-0.20	-0.27	-0.08	0.02	-0.18	-0.25	0.03	-0.04	-0.06	-0.04	-0.02	-0.08
11	13.00	26.00	28.00	9.00	50.00	42.00	46.00	0.21	0.46	0.54	0.19	0.45	0.39	0.43	-0.26	-0.34	-0.08	-0.02	-0.27	-0.35	0.07	0.02	-0.05	-0.26	-0.20	-0.24
12	2.00	4.00	2.00	2.00	1.00	0.00	8.00	0.22	0.48	0.55	0.20	0.46	0.39	0.47	-0.27	-0.34	-0.07	-0.02	-0.29	-0.36	0.07	-0.01	-0.08	-0.26	-0.19	-0.27
13	2.00	0.00	0.00	0.00	0.00	0.00	1.00	0.23	0.48	0.55	0.20	0.46	0.39	0.47	-0.26	-0.33	-0.07	-0.03	-0.29	-0.36	0.07	-0.02	-0.09	-0.26	-0.19	-0.28
14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.23	0.48	0.55	0.20	0.46	0.39	0.47	-0.26	-0.33	-0.07	-0.03	-0.29	-0.36	0.07	-0.02	-0.09	-0.26	-0.19	-0.28
15	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.23	0.48	0.56	0.20	0.46	0.39	0.47	-0.26	-0.33	-0.07	-0.03	-0.29	-0.36	0.07	-0.02	-0.09	-0.26	-0.19	-0.28
16	1.00	4.00	2.00	1.00	6.00	2.00	4.00	0.23	0.51	0.57	0.20	0.49	0.40	0.49	-0.27	-0.33	-0.06	-0.03	-0.30	-0.37	0.09	0.00	-0.10	-0.29	-0.19	-0.29
17	19.00	10.00	6.00	69.00	1.00	3.00	0.00	0.34	0.56	0.60	0.46	0.49	0.41	0.49	-0.22	-0.26	-0.04	0.13	-0.09	-0.13	0.08	0.00	-0.08	-0.03	0.05	-0.03
18	31.00	3.00	0.00	2.00	2.00	0.00	0.00	0.51	0.57	0.60	0.47	0.50	0.41	0.49	-0.07	-0.09	-0.03	-0.03	-0.10	-0.13	0.09	0.01	-0.08	-0.03	0.06	-0.02
19	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.51	0.57	0.60	0.47	0.50	0.41	0.50	-0.07	-0.09	-0.03	-0.03	-0.10	-0.13	0.09	0.01	-0.08	-0.03	0.06	-0.02
20	1.00	0.00	1.00	1.00	7.00	4.00	0.00	0.51	0.57	0.60	0.48	0.54	0.43	0.50	-0.06	-0.09	-0.03	-0.04	-0.10	-0.13	0.11	0.04	-0.06	-0.06	0.04	-0.02
21	1.00	0.00	0.00	3.00	2.00	0.00	0.00	0.52	0.57	0.60	0.49	0.55	0.43	0.50	-0.06	-0.09	-0.03	-0.03	-0.08	-0.12	0.12	0.05	-0.06	-0.06	0.06	-0.01
22	52.00	20.00	19.00	32.00	15.00	10.00	11.00	0.80	0.67	0.69	0.61	0.62	0.48	0.54	0.13	0.10	-0.02	-0.19	-0.07	-0.09	0.14	0.08	-0.06	-0.02	0.13	0.06
23	4.00	5.00	7.00	4.00	7.00	10.00	17.00	0.82	0.70	0.73	0.62	0.66	0.53	0.62	0.12	0.09	-0.03	-0.20	-0.08	-0.10	0.13	0.04	-0.08	-0.04	0.09	0.01
24	3.00	6.00	7.00	8.00	36.00	50.00	22.00	0.84	0.73	0.76	0.65	0.84	0.79	0.71	0.11	0.07	-0.03	-0.18	-0.08	-0.11	0.06	0.13	0.07	-0.19	-0.13	-0.06
25	0.00	0.00	0.00	1.00	0.00	2.00	1.00	0.84	0.73	0.76	0.66	0.84	0.80	0.72	0.11	0.07	-0.03	-0.18	-0.07	-0.10	0.05	0.13	0.08	-0.18	-0.14	-0.06
26	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.84	0.73	0.76	0.66	0.84	0.80	0.72	0.11	0.07	-0.03	-0.18	-0.07	-0.10	0.05	0.13	0.08	-0.18	-0.14	-0.06
27	24.00	30.00	11.00	23.00	13.00	19.00	20.00	0.97	0.88	0.82	0.75	0.91	0.89	0.80	0.08	0.15	0.07	-0.22	-0.13	-0.07	0.02	0.10	0.09	-0.16	-0.14	-0.06
28	0.00	4.00	9.00	2.00	1.00	3.00	0.00	0.97	0.90	0.86	0.76	0.91	0.91	0.80	0.06	0.11	0.04	-0.21	-0.15	-0.10	0.01	0.11	0.10	-0.16	-0.15	-0.05
29	0.00	0.00	2.00	2.00	0.00	0.00	5.00	0.97	0.90	0.87	0.76	0.91	0.91	0.83	0.06	0.10	0.03	-0.20	-0.14	-0.10	0.01	0.09	0.08	-0.15	-0.14	-0.06
30	1.00	1.00	4.00	7.00	1.00	4.00	3.00	0.97	0.91	0.89	0.79	0.92	0.93	0.84	0.06	0.08	0.02	-0.18	-0.12	-0.10	-0.01	0.08	0.09	-0.13	-0.14	-0.05
31	1.00	1.00	1.00	0.00	3.00	0.00	2.00	0.98	0.91	0.89	0.79	0.93	0.93	0.85	0.06	0.09	0.02	-0.19	-0.12	-0.10	0.01	0.09	0.08	-0.14	-0.14	-0.06
32	2.00	10.00	14.00	47.00	12.00	4.00	25.00	0.99	0.96	0.96	0.97	0.99	0.95	0.96	0.02	0.03	0.00	-0.02	0.01	0.01	0.05	0.04	-0.01	-0.03	0.02	0.01
33	1.00	0.00	0.00	0.00	0.00	6.00	2.00	0.99	0.96	0.96	0.97	0.99	0.98	0.97	0.03	0.03	0.00	-0.02	0.01	0.01	0.02	0.03	0.01	-0.03	-0.01	0.00
34	0.00	7.00	6.00	0.00	1.00	2.00	1.00	0.99	1.00	0.99	0.97	1.00	0.99	0.97	-0.01	0.00	0.01	-0.02	-0.03	-0.02	0.01	0.03	0.02	-0.03	-0.02	0.00
35	0.00	0.00	0.00	6.00	0.00	0.00	5.00	0.99	1.00	0.99	0.99	1.00	0.99	0.99	-0.01	0.00	0.01	0.00	-0.01	0.00	0.01	0.01	0.00	-0.01	0.00	0.00
36	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.99	1.00	0.99	0.99	1.00	0.99	0.99	-0.01	0.00	0.01	0.00	-0.01	0.00	0.01	0.01	0.00	-0.01	0.00	0.00
37	1.00	0.00	2.00	2.00	0.00	2.00	2.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
38	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table G17: ECOLOGY RESERVE SAMPLES, DATA FOR KOLMOGOROV-SMIRNOV TWO TAIL TEST

Table G18: MACQUARIE UNIVERSITY CODES FOR SLIDES USED IN SCANNING, PILLIGA SITE 8 SHEETING, DOMES, FAUNAL, A & B HORIZON SAMPLES*

Sample #	Description	Location	Macquarie University #
1	sheeting	Pilliga 8	MU 50599
4	A horizon		MU 50602
D1	Dome		MU 50605
B1	B horizon		MU 50606
F1	Faunal		MU 50607

* For Tables G19 and G20

Morphological Type		Morph #	Sheeting Total	Sheeting %	Sheeting % Cum	A Horizon Total	A Horizon %	A Horizon % Cum	Domes Total	Domes %	Domes % Cum	B Horizon Total	B Horizon %	B Horizon % Cum	Faunal Total	Faunal %	Faunal % Cum
Lobates	bilobates	1	11.0	5.6	5.6	16.0	7.8	7.8	16.0	7.6	7.6	21.0	9.6	9.6	8.0	7.5	7.5
	polylobates	2	0.0	0.0	5.6	0.0	0.0	7.8	0.0	0.0	7.6	0.0	0.0	9.6	0.0	0.0	7.5
	crosses	3	0.0	0.0	5.6	0.0	0.0	7.8	0.0	0.0	7.6	0.0	0.0	9.6	1.0	0.9	8.4
Saddles		4	1.0	0.5	6.1	1.0	0.5	8.3	4.0	1.9	9.5	5.0	2.3	11.9	0.0	0.0	8.4
Dble Outlines		5	3.0	1.5	7.6	5.0	2.5	10.8	8.0	3.8	13.3	11.0	5.0	16.9	4.0	3.7	12.1
Cones		6	8.0	4.0	11.6	1.0	0.5	11.3	4.0	1.9	15.2	5.0	2.3	19.2	2.0	1.9	14.0
Rods: thick	smooth	7	10.0	5.1	16.7	12.0	5.9	17.2	14.0	6.6	21.8	5.0	2.3	21.5	2.0	1.9	15.9
	spiked	8	5.0	2.5	19.2	6.0	2.9	20.1	11.0	5.2	27.0	4.0	1.8	23.3	3.0	2.8	18.7
	jigsaw	9	1.0	0.5	19.7	4.0	2.0	22.1	6.0	2.8	29.9	2.0	0.9	24.2	1.0	0.9	19.6
	ridged	10	2.0	1.0	20.7	3.0	1.5	23.5	4.0	1.9	31.8	1.0	0.5	24.7	6.0	5.6	25.2
	rough	11	31.0	15.7	36.4	26.0	12.7	36.3	22.0	10.4	42.2	13.0	5.9	30.6	8.0	7.5	32.7
Rods: thin	smooth	12	0.0	0.0	36.4	0.0	0.0	36.3	2.0	0.9	43.1	3.0	1.4	32.0	2.0	1.9	34.6
	spiked	13	0.0	0.0	36.4	0.0	0.0	36.3	2.0	0.9	44.1	0.0	0.0	32.0	0.0	0.0	34.6
	jigsaw	14	0.0	0.0	36.4	0.0	0.0	36.3	0.0	0.0	44.1	0.0	0.0	32.0	0.0	0.0	34.6
	ridged	15	0.0	0.0	36.4	0.0	0.0	36.3	0.0	0.0	44.1	1.0	0.5	32.4	1.0	0.9	35.5
	rough	16	2.0	1.0	37.4	4.0	2.0	38.2	2.0	0.9	45.0	8.0	3.7	36.1	0.0	0.0	35.5
Rods: platey	jigsaw	17	0.0	0.0	37.4	0.0	0.0	38.2	0.0	0.0	45.0	0.0	0.0	36.1	2.0	1.9	37.4
	sinuous	18	1.0	0.5	37.9	0.0	0.0	38.2	4.0	1.9	46.9	0.0	0.0	36.1	0.0	0.0	37.4
Sheets 2D reg	honeycomb	19	0.0	0.0	37.9	0.0	0.0	38.2	0.0	0.0	46.9	0.0	0.0	36.1	3.0	2.8	40.2
	plain	20	0.0	0.0	37.9	0.0	0.0	38.2	0.0	0.0	46.9	0.0	0.0	36.1	1.0	0.9	41.1
	perforated	21	1.0	0.5	38.4	0.0	0.0	38.2	4.0	1.9	48.8	3.0	1.4	37.4	17.0	15.9	57.0
	bulbous	22	4.0	2.0	40.4	0.0	0.0	38.2	1.0	0.5	49.3	0.0	0.0	37.4	6.0	5.6	62.6
Sheets 3D reg	smooth	23	5.0	2.5	42.9	11.0	5.4	43.6	12.0	5.7	55.0	9.0	4.1	41.6	2.0	1.9	64.5
	rough	24	29.0	14.6	57.6	26.0	12.7	56.4	11.0	5.2	60.2	19.0	8.7	50.2	7.0	6.5	71.0
	honeycomb	25	1.0	0.5	58.1	0.0	0.0	56.4	0.0	0.0	60.2	0.0	0.0	50.2	0.0	0.0	71.0
	verrucose	26	1.0	0.5	58.6	0.0	0.0	56.4	0.0	0.0	60.2	0.0	0.0	50.2	0.0	0.0	71.0
Hairs & Prickles	long	27	32.0	16.2	74.7	30.0	14.7	71.1	25.0	11.8	72.0	24.0	11.0	61.2	9.0	8.4	79.4
	short	28	2.0	1.0	75.8	0.0	0.0	71.1	8.0	3.8	75.8	8.0	3.7	64.8	0.0	0.0	79.4
	gourds	29	10.0	5.1	80.8	10.0	4.9	76.0	2.0	0.9	76.8	3.0	1.4	66.2	3.0	2.8	82.2
Spheres: single	smooth	30	6.0	3.0	83.8	3.0	1.5	77.5	8.0	3.8	80.6	8.0	3.7	69.9	1.0	0.9	83.2
	spiked	31	0.0	0.0	83.8	1.0	0.5	77.9	0.0	0.0	80.6	4.0	1.8	71.7	0.0	0.0	83.2
	rough	32	21.0	10.6	94.4	31.0	15.2	93.1	30.0	14.2	94.8	51.0	23.3	95.0	16.0	15.0	98.1
	indented	33	0.0	0.0	94.4	2.0	1.0	94.1	2.0	0.9	95.7	0.0	0.0	95.0	0.0	0.0	98.1
	verrucose	34	0.0	0.0	94.4	2.0	1.0	95.1	0.0	0.0	95.7	0.0	0.0	95.0	0.0	0.0	98.1
Spheres: compound	smooth	35	2.0	1.0	95.5	3.0	1.5	96.6	3.0	1.4	97.2	4.0	1.8	96.8	0.0	0.0	98.1
	spiked	36	0.0	0.0	95.5	0.0	0.0	96.6	0.0	0.0	97.2	0.0	0.0	96.8	0.0	0.0	98.1
	rough	37	9.0	4.5	100.0	7.0	3.4	100.0	6.0	2.8	100.0	7.0	3.2	100.0	2.0	1.9	100.0
	indented	38	0.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0	100.0	0.0	0.0	100.0
		Total	198.0			204.0			211.0			219.0			107.0		

OTHERS			Sheeting	% WHOLE SAMPLE	A Horizon	% WHOLE SAMPLE	Domes	% WHOLE SAMPLE	B Horizon	% WHOLE SAMPLE	Faunal	% WHOLE SAMPLE
Sheets 2D nonreg			316.0	57.1	212.0	44.4	80.0	23.7	48.0	17.1	201.0	58.1
Sheets 3D nonreg	smooth		3.0	0.5	2.0	0.4	6.0	1.8	4.0	1.4	9.0	2.6
	rough		16.0	2.9	13.0	2.7	6.0	1.8	4.0	1.4	21.0	6.1
Unclassified silica			3.0	0.5	5.0	1.0	30.0	8.9	2.0	0.7	6.0	1.7
Other silica			17.0	3.1	42.0	8.8	5.0	1.5	4.0	1.4	2.0	0.6
		Total	355.0		274.0		127.0		62.0		239.0	

Table G19: SCANNING, PILLIGA SITE 8
SHEETING, DOMES, FAUNAL, A & B HORIZONS

MORPH #	TOTALS					CUMULATIVE P					COMPARISONS									
	sheet	A	Domes	B	faunal	sheet	A	Domes	B	faunal	sh/A	sh/Domes	sh/B	sh/faunal	A/Domes	A/B	A/faunal	Domes/B	Domes/fnl	B/fnl
1	11.00	16.00	16.00	21.00	8.00	0.06	0.08	0.08	0.10	0.07	-0.02	-0.02	-0.04	-0.02	0.00	-0.02	0.00	-0.02	0.00	0.02
2	0.00	0.00	0.00	0.00	0.00	0.06	0.08	0.08	0.10	0.07	-0.02	-0.02	-0.04	-0.02	0.00	-0.02	0.00	-0.02	0.00	0.02
3	0.00	0.00	0.00	0.00	1.00	0.06	0.08	0.08	0.10	0.08	-0.02	-0.02	-0.04	-0.03	0.00	-0.02	-0.01	-0.02	-0.01	0.01
4	1.00	1.00	4.00	5.00	0.00	0.06	0.08	0.09	0.12	0.08	-0.02	-0.03	-0.06	-0.02	-0.01	-0.04	0.00	-0.02	0.01	0.03
5	3.00	5.00	8.00	11.00	4.00	0.08	0.11	0.13	0.17	0.12	-0.03	-0.06	-0.09	-0.05	-0.02	-0.06	-0.01	-0.04	0.01	0.05
6	8.00	1.00	4.00	5.00	2.00	0.12	0.11	0.15	0.19	0.14	0.00	-0.04	-0.08	-0.02	-0.04	-0.08	-0.03	-0.04	0.01	0.05
7	10.00	12.00	14.00	5.00	2.00	0.17	0.17	0.22	0.21	0.16	0.00	-0.05	-0.05	0.01	-0.05	-0.04	0.01	0.00	0.06	0.06
8	5.00	6.00	11.00	4.00	3.00	0.19	0.20	0.27	0.23	0.19	-0.01	-0.08	-0.04	0.01	-0.07	-0.03	0.01	0.04	0.08	0.05
9	1.00	4.00	6.00	2.00	1.00	0.20	0.22	0.30	0.24	0.20	-0.02	-0.10	-0.05	0.00	-0.08	-0.02	0.02	0.06	0.10	0.05
10	2.00	3.00	4.00	1.00	6.00	0.21	0.24	0.32	0.25	0.25	-0.03	-0.11	-0.04	-0.05	-0.08	-0.01	-0.02	0.07	0.07	-0.01
11	31.00	26.00	22.00	13.00	8.00	0.36	0.36	0.42	0.31	0.33	0.00	-0.06	0.06	0.04	-0.06	0.06	0.04	0.12	0.09	-0.02
12	0.00	0.00	2.00	3.00	2.00	0.36	0.36	0.43	0.32	0.35	0.00	-0.07	0.04	0.02	-0.07	0.04	0.02	0.11	0.09	-0.03
13	0.00	0.00	2.00	0.00	0.00	0.36	0.36	0.44	0.32	0.35	0.00	-0.08	0.04	0.02	-0.08	0.04	0.02	0.12	0.09	-0.03
14	0.00	0.00	0.00	0.00	0.00	0.36	0.36	0.44	0.32	0.35	0.00	-0.08	0.04	0.02	-0.08	0.04	0.02	0.12	0.09	-0.03
15	0.00	0.00	0.00	1.00	1.00	0.36	0.36	0.44	0.32	0.36	0.00	-0.08	0.04	0.01	-0.08	0.04	0.01	0.12	0.09	-0.03
16	2.00	4.00	2.00	8.00	0.00	0.37	0.38	0.45	0.36	0.36	-0.01	-0.08	0.01	0.02	-0.07	0.02	0.03	0.09	0.10	0.01
17	0.00	0.00	0.00	0.00	2.00	0.37	0.38	0.45	0.36	0.37	-0.01	-0.08	0.01	0.00	-0.07	0.02	0.01	0.09	0.08	-0.01
18	1.00	0.00	4.00	0.00	0.00	0.38	0.38	0.47	0.36	0.37	0.00	-0.09	0.02	0.00	-0.09	0.02	0.01	0.11	0.10	-0.01
19	0.00	0.00	0.00	0.00	3.00	0.38	0.38	0.47	0.36	0.40	0.00	-0.09	0.02	-0.02	-0.09	0.02	-0.02	0.11	0.07	-0.04
20	0.00	0.00	0.00	0.00	1.00	0.38	0.38	0.47	0.36	0.41	0.00	-0.09	0.02	-0.03	-0.09	0.02	-0.03	0.11	0.06	-0.05
21	1.00	0.00	4.00	3.00	17.00	0.38	0.38	0.49	0.37	0.57	0.00	-0.10	0.01	-0.19	-0.11	0.01	-0.19	0.11	-0.08	-0.20
22	4.00	0.00	1.00	0.00	6.00	0.40	0.38	0.49	0.37	0.63	0.02	-0.09	0.03	-0.22	-0.11	0.01	-0.24	0.12	-0.13	-0.25
23	5.00	11.00	12.00	9.00	2.00	0.43	0.44	0.55	0.42	0.64	-0.01	-0.12	0.01	-0.22	-0.11	0.02	-0.21	0.13	-0.10	-0.23
24	29.00	26.00	11.00	19.00	7.00	0.58	0.56	0.60	0.50	0.71	0.01	-0.03	0.07	-0.13	-0.04	0.06	-0.15	0.10	-0.11	-0.21
25	1.00	0.00	0.00	0.00	0.00	0.58	0.56	0.60	0.50	0.71	0.02	-0.02	0.08	-0.13	-0.04	0.06	-0.15	0.10	-0.11	-0.21
26	1.00	0.00	0.00	0.00	0.00	0.59	0.56	0.60	0.50	0.71	0.02	-0.02	0.08	-0.12	-0.04	0.06	-0.15	0.10	-0.11	-0.21
27	32.00	30.00	25.00	24.00	9.00	0.75	0.71	0.72	0.61	0.79	0.04	0.03	0.14	-0.05	-0.01	0.10	-0.08	0.11	-0.07	-0.18
28	2.00	0.00	8.00	8.00	0.00	0.76	0.71	0.76	0.65	0.79	0.05	0.00	0.11	-0.04	-0.05	0.06	-0.08	0.11	-0.04	-0.15
29	10.00	10.00	2.00	3.00	3.00	0.81	0.76	0.77	0.66	0.82	0.05	0.04	0.15	-0.01	-0.01	0.10	-0.06	0.11	-0.05	-0.16
30	6.00	3.00	8.00	8.00	1.00	0.84	0.77	0.81	0.70	0.83	0.06	0.03	0.14	0.01	-0.03	0.08	-0.06	0.11	-0.03	-0.13
31	0.00	1.00	0.00	4.00	0.00	0.84	0.78	0.81	0.72	0.83	0.06	0.03	0.12	0.01	-0.03	0.06	-0.05	0.09	-0.03	-0.11
32	21.00	31.00	30.00	51.00	16.00	0.94	0.93	0.95	0.95	0.98	0.01	0.00	-0.01	-0.04	-0.02	-0.02	-0.05	0.00	-0.03	-0.03
33	0.00	2.00	2.00	0.00	0.00	0.94	0.94	0.96	0.95	0.98	0.00	-0.01	-0.01	-0.04	-0.02	-0.01	-0.04	0.01	-0.02	-0.03
34	0.00	2.00	0.00	0.00	0.00	0.94	0.95	0.96	0.95	0.98	-0.01	-0.01	-0.01	-0.04	-0.01	0.00	-0.03	0.01	-0.02	-0.03
35	2.00	3.00	3.00	4.00	0.00	0.95	0.97	0.97	0.97	0.98	-0.01	-0.02	-0.01	-0.03	-0.01	0.00	-0.02	0.00	-0.01	-0.01
36	0.00	0.00	0.00	0.00	0.00	0.95	0.97	0.97	0.97	0.98	-0.01	-0.02	-0.01	-0.03	-0.01	0.00	-0.02	0.00	-0.01	-0.01
37	9.00	7.00	6.00	7.00	2.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
38	0.00	0.00	0.00	0.00	0.00	1.00	1.00	1.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table G20: PILLIGA SITE 8 SAMPLES: DATA FOR KOLMOGOROV-SMIRNOV TWO TAIL TEST

Table G21: SURFACE AREA OF PLATES, ECOLOGY RESERVE LITTER AND ASH

RANGE	ASH DAY 2		ASH DAY 14		ASH DAY 30		LITTER 3	
(sq um)	(MU 50629)		(MU 50630)		(MU 50631)		(MU 50590)	
hundreds	number	%	number	%	number	%	number	%
0-1,000	61	84	14	88	9	100	45	62
1,001-2,000	9	12	2	13	0	0	3	4
2,001-3,000	1	1	0	0	0	0	4	5
3,001-4,000	1	1	0	0	0	0	2	3
4,001-5,000	0	0	0	0	0	0	2	3
5,001-6,000	0	0	0	0	0	0	3	4
6,001-7,000	0	0	0	0	0	0	0	0
7,001-8,000	0	0	0	0	0	0	0	0
8,001-9,000	0	0	0	0	0	0	1	1
9,001-10,000	0	0	0	0	0	0	0	0
10,001-11,000	0	0	0	0	0	0	1	1
11,001-12,000	0	0	0	0	0	0	0	0
12,001-13,000	0	0	0	0	0	0	1	1
13,001-14,000	0	0	0	0	0	0	0	0
14,001-15,000	0	0	0	0	0	0	2	3
15,001-16,000	0	0	0	0	0	0	4	5
16,001-17,000	0	0	0	0	0	0	0	0
17,001-18,000	0	0	0	0	0	0	2	3
18,001-19,000	0	0	0	0	0	0	0	0
19,001-20,000	0	0	0	0	0	0	1	1
20,001-21,000	0	0	0	0	0	0	1	1
21,001-22,000	0	0	0	0	0	0	0	0
22,001-23,000	0	0	0	0	0	0	0	0
23,001-24,000	0	0	0	0	0	0	1	1
24,001-25,000	0	0	0	0	0	0	0	0
n	73		16		9		73	
Average	564.4		526.1		311.9		3,705.66	
Std Deviation	556.4		440.2		258.6		6,123.37	

Table G22: SURFACE AREA OF PLATES UNDER 100,000 sq um
ECOLOGY RESERVE LITTER AND ASH

RANGE (sq um) hundreds	ASH DAY 2 (MU 50629) number	%	ASH DAY 14 (MU 50630) number	%	ASH DAY 30 (MU 50631) number	%	LITTER 3 (MU 50590) number	%
0-100	7	11	2	14	1	11	18	40
101-200	12	20	1	7	3	33	10	22
201-300	9	15	2	14	2	22	3	7
301-400	8	13	5	36	1	11	3	7
401-500	5	8	1	7	0	0	2	4
501-600	6	10	2	14	1	11	3	7
601-700	7	11	0	0	0	0	1	2
701-800	5	8	0	0	0	0	2	4
801-900	2	3	1	7	1	11	0	0
901-1,000	0	0	0	0	0	0	3	7
n	61		14		9		45	

Table G23: OXFORD FALLS PODZOL (PROFILE OF2)
DEPTH DISTRIBUTION OF PLANT OPAL

Depth metres	% opal
-0.45	1.28
-0.4	0.53
-0.3	0.89
-0.2	1.2
-0.05	4.19
0	4.19

Table G24: PILLIGA SITE 8, MALLEE
DEPTH DISTRIBUTION OF PLANT OPAL
(INITIAL SAMPLING)

Horizon	% sand	% silt	% clay	opal x silt
Domes	65.17	9.32	25.49	0.018
B horizon	34.29	4.15	61.62	0.008

Table G25: ECOLOGY RESERVE SITE 3 (PROFILE ER3)
DEPTH DISTRIBUTION OF PLANT OPAL

Depth metres	% opal x silt	% clay
-1	0.3	20.9
-0.6	0.5	22.1
-0.25	0.3	8.3
-0.1	0.1	5
0	0	0

Table G26: PILLIGA SITE 8, MALLEE (PROFILE PF8i)
DEPTH DISTRIBUTION OF PLANT OPAL

Depth metres	Material or Horizon	% opal x silt	% clay
-0.3	Faunal channels	0.009	61.1
-0.2	B horizon	0.001	39.5
-0.1	Dome	0.002	17.5
-0.05	A horizon	0.006	23.7
0	Surface	0	0
0.02	Sheeting	0.009	28.1

Table G27: RESULTS OF POINT COUNTING, CYPERACEAE-TYPE PLANT OPAL

MU #	Species #	Material	Sample #	n	P (SE) (95% level)
MU 50528	3	Banksia oblongifolia	1	236	0.021 (0.009)
MU 50529			2	202	0.015 (0.009)
MU 50530	9	Acacia schinoides	1	226	0.113 (0.044)
MU 50531			2	228	0.125 (0.014)
MU 50532	11	Casuarina distyla	1	240	trace
MU 50533			2	240	trace
MU 50534	14	Gahnia sieberana	1	213	0.465 (0.067)
MU 50535			2	261	0.498 (0.031)
MU 50536	79	A. tindaleae			
MU 50537	80	A. burrowii			
MU 50538	81	A. calamifolia	1		trace
MU 50539	82	A. spectabilis	1		trace
MU 50540	83	A. dorotoxylon			
MU 50541	84	A. deanei ssp deanei	1	226	0.018 (0.009)
MU 50542	85	A. lineata	1	212	0.009 (0.006)
MU 50543	86	A. triptera	1	136	trace

Table G28: RESULTS OF POINT COUNTING, PURITY OF LITTER EXTRACTIONS

MU #	Material	Site	Sample #	n	P (SE) (95% level)
MU 50544	leaves	Pilliga 7	1	209	0.96 (0.013)
MU 50545			2	206	0.93 (0.018)
MU 50546			3	210	0.97 (0.012)
MU 50547	twigs		1	212	0.82 (0.026)
MU 50548			2	198	0.84 (0.025)
MU 50549	bark		1	200	0.91 (0.020)
MU 50550			2	199	0.87 (0.024)
MU 50551	residue		1	221	0.97 (0.011)
MU 50552			2	224	0.49 (0.033)
MU 50553			3	207	0.97 (0.012)
MU 50554	biomass		1	222	0.59 (0.033)
MU 50555	leaves	Pilliga 8	1	214	0.99 (0.007)
MU 50556			2	217	0.99 (0.007)
MU 50557			3	200	0.99 (0.007)
MU 50558	twigs		1	212	0.73 (0.030)
MU 50559			2	215	0.74 (0.030)
MU 50560	bark		1	210	0.98 (0.010)
MU 50561			3	217	0.97 (0.012)
MU 50562	faecal		1	208	0.99 (0.007)
MU 50563			2	204	0.97 (0.012)
MU 50564			3	222	0.98 (0.009)
MU 50565	residue		1	250	0.99 (0.007)
MU 50566			2	190	0.93 (0.018)
MU 50567			3	248	0.93 (0.016)
MU 50568	biomass		1	205	0.94 (0.017)
MU 50569			2	197	1
MU 50570			3	144	0.59 (0.430)
MU 50571	leaves	Pilliga 12	1	225	0.96 (0.013)
MU 50572			2	229	0.87 (0.022)
MU 50573			3	198	0.89 (0.022)
MU 50574	twigs		1	207	0.90 (0.021)
MU 50575			2	208	0.91 (0.020)
MU 50576			3	215	0.76 (0.029)
MU 50577	bark		1	200	0.68 (0.033)
MU 50578	residue		1	268	0.84 (0.022)
MU 50579			2	198	0.88 (0.023)
MU 50580			3	141	0.92 (0.023)
MU 50581	biomass		1	213	0.63 (0.330)
MU 50582			2	227	0.79 (0.027)
MU 50583			3	254	0.79 (0.026)
MU 50584	bulk	Pilliga 7	1	207	0.82 (0.027)
MU 50585	litter	Pilliga 8	1	201	0.88 (0.023)
MU 50586		Pilliga 9	1	202	0.87 (0.024)
MU 50587		Pilliga 12	1	198	0.84 (0.026)
MU 50588		Ecol 1	1		
MU 50589		Ecol 2	1		
MU 50590		Ecol 3	1	232	0.89 (0.020)

Table G29: SITE 8, MALLEE, PERCENTAGE FAUNAL CHANNELS WITH DEPTH (SAMPLE NEAR PF8ii)

MU #	Depth (mm)	Horizon	% channels
MU 50524	0	A1	0
MU 50524	-10		14.4
MU 50524	-20		20.8
MU 50524	-30		6.3
MU 50524	-40		8.7
MU 50525	-60	A2	4
MU 50525	-70		2.6
MU 50525	-80		3.7
MU 50526	-90	Dome Top	1.1
MU 50526	-110		1.1
MU 50526	-120		5.8
MU 50526	-130		2.6
MU 50526	-140		3.4
MU 50527	-150	B1	2.5
MU 50527	-160		3.7
MU 50527	-170		3.2
MU 50527	-180		2.8
MU 50527	-190		1.9
MU 50527	-200		2.1

CODES OF SAMPLES HELD IN THE MUSEUM OF THE
SCHOOL OF EARTH SCIENCES, MACQUARIE UNIVERSITY

Macquarie University #	Sample #	Description	Location
	SEM stubs		
MU 50476	8513	organic pan	Nar
MU 50477	8531	Banksia asplenifolia	OF
MU 50478	8538	Core 1:1	OF
MU 50479	8560	Core 1:1	OF
MU 50480	8601	faunal, B	Pil 8
MU 50481	8619	D1	Pil 8
MU 50482	8620	D2	Pil 8
MU 50483	8621	B1	Pil 8
MU 50484	8622	B2	Pil 8
MU 50485	8625	organic pan	Nar
MU 50486	8627	organic pan	Nar
MU 50487	8629	Pteridium esculentum	OF
MU 50488	8631	Unk 1	OF
MU 50489	8734	E gummifera	OF
MU 50490	8739	Melaleuca uncinata	Pil 1
MU 50491	8740	Stipa sp 37a	Pil
MU 50492	8741	Stipa sp 37a	Pil
MU 50493	8745	Calytrix tetragona	Pil 2
MU 50494	8746	Dodonaea viscosa ssp cuneata	Pil 8
MU 50495	8747	Dodonaea viscosa ssp cuneata	Pil 8
MU 50496	8756	sediment A1	Bot Gardens
MU 50497	8758	sediment A1	Bot Gardens
MU 50498	8759	sediment A1	Bot Gardens
MU 50499	8777	Stipa	West
MU 50500	8778	Stipa	West
MU 50501	8781	Stipa sp 79	West
MU 50502	8786	Stipa sp 76	West
MU 50503	8883	Carton	Pil
MU 50504	8884	Podzol A1 0-5cm	OF
MU 50505	8885	Podzol 0-5cm	OF
MU 50506	8887	Podzol A2 15-20cm	OF
MU 50507	8892	Podzol 40-45cm	OF
MU 50508	8893	Podzol 40-45cm	OF
MU 50509	8896	Channel, B	Pil 8
MU 50510	8913	Acacia calanafolia	Pil
MU 50511	8914	Acacia spectabilis	Pil
MU 50512	8916	Acacia deanei ssp deanei	Pil
MU 50513	8917	Acacia lineata	Pil
MU 50514	8918	Acacia triptera	Pil
MU 50515	9002	silt A1	Pil 12b
MU 50516	9003	silt A1	Pil 7b
MU 50517	9006	silt A1	Pil 8a
MU 50518	9007	silt A1	Pil 8b
MU 50519	9008	silt A1	Pil 9a
MU 50520	9013	silt A1	Ecol site 3
MU 50521	9014	silt A1	Ecol site 3
MU 50522	9016	sand	Ecol ash
MU 50523	9018	ash	Ecol ash

CODES OF SAMPLES HELD IN THE MUSEUM OF THE
SCHOOL OF EARTH SCIENCES, MACQUARIE UNIVERSITY (CONT'D)

Macquarie University #	Sample #	Description	Location
	Kubiena tins		
MU 50524	A1	sliced	Pilliga 8
MU 50525	A2	sliced	Pilliga 8
MU 50526	Dome top	sliced	Pilliga 8
MU 50527	B1	sliced	Pilliga 8
	Species slides		
MU 50528	3 1	Banksia oblongifolia	Pilliga
MU 50529	3 2		Pilliga
MU 50530	9 1	Acacia schinoides	Pilliga
MU 50531	9 2		Pilliga
MU 50532	11 1	Casuarina distyla	Pilliga
MU 50533	11 2		Pilliga
MU 50534	14 1	Gahnia sieberana	Pilliga
MU 50535	14 2		Pilliga
MU 50536	79	A. tindaleae	Pilliga
MU 50537	80	A. burrowii	Pilliga
MU 50538	81	A. calamifolia	Pilliga
MU 50539	82	A. spectabilis	Pilliga
MU 50540	83	A. dorotoxylon	Pilliga
MU 50541	84	A. deanei ssp deanei	Pilliga
MU 50542	85	A. lineata	Pilliga
MU 50543	86	A. triptera	Pilliga
	Litter slides		
MU 50544	1	leaves	Pilliga 7
MU 50545	2		
MU 50546	3		
MU 50547	1	twigs	
MU 50548	2		
MU 50549	1	bark	
MU 50550	2		
MU 50551	1	residue	
MU 50552	2		
MU 50553	3		
MU 50554	1	biomass	
MU 50555	1	leaves	Pilliga 8
MU 50556	2		
MU 50557	3		
MU 50558	1	twigs	
MU 50559	2		
MU 50560	1	bark	
MU 50561	3		
MU 50562	1	faecal	
MU 50563	2		
MU 50564	3		
MU 50565	1	residue	
MU 50566	2		
MU 50567	3		
MU 50568	1	biomass	
MU 50569	2		
MU 50570	3		

CODES OF SAMPLES HELD IN THE MUSEUM OF THE
SCHOOL OF EARTH SCIENCES, MACQUARIE UNIVERSITY (CONT'D)

Macquarie University #	Sample #	Description	Location
MU 50571	1	leaves	Pilliga 12
MU 50572	2		
MU 50573	3		
MU 50574	1	twigs	
MU 50575	2		
MU 50576	3		
MU 50577	1	bark	
MU 50578	1	residue	
MU 50579	2		
MU 50580	3		
MU 50581	1	biomass	
MU 50582	2		
MU 50583	3		
MU 50584	1	bulk	Pilliga 7a
MU 50585	1	litter	Pilliga 8a
MU 50586	1		Pilliga 9b
MU 50587	1		Pilliga 12b
MU 50588	1		Ecol 1
MU 50589	1		Ecol 2
MU 50590	1		Ecol 3
	Slides of plant opal from sediment		
MU 50591	E1	soil, 0-50mm	Ecol 1
MU 50592	E2	soil, 100-200mm	
MU 50593	E3	soil, 0-50mm	Ecol 2
MU 50594	E4	soil, 400-500mm	
MU 50595	E5	soil, 0-100mm	Ecol 3
MU 50596	E6	soil, 200-250mm	
MU 50597	E7	soil, 500-600mm	
MU 50598	E8	soil, 1000mm+	
MU 50599	1	sheeting	Pilliga 8
MU 50600	2		
MU 50601	3		
MU 50602	4	A horizon	
MU 50603	5		
MU 50604	6		
MU 50605	D1	Dome	
MU 50606	B1	B horizon	
MU 50607	F1	Faunal	
MU 50608	2/1	pinch	Pilliga 2
MU 50609	2/2		
MU 50610	6/1	pinch	Pilliga 6
MU 50611	6/2		
MU 50612	7a2	pinch	Pilliga 7
MU 50613	7b2		
MU 50614	8a2	pinch	Pilliga 8
MU 50615	9a1	pinch	Pilliga 9
MU 50616	12a1	pinch	Pilliga 12
MU 50617	2a	pinch	Ecol ash
MU 50618	5a	pinch	Ecol ash
MU 50619	8a	pinch	Ecol ash

CODES OF SAMPLES HELD IN THE MUSEUM OF THE
SCHOOL OF EARTH SCIENCES, MACQUARIE UNIVERSITY (CONT'D)

Macquarie University #	Sample #	Description	Location
	Slides for processing examination		
MU 50620	6/1	sand	Pilliga 6
MU 50621	6/1i	first decantation	Pilliga 6
MU 50622	6/1i	sink	Pilliga 6
MU 50623	6/1	clay	Pilliga 6
	Slides for soil examination and infiltration expe		
MU 50624	diatoms	diatoms	Chalk Mt
MU 50625	A1	soil, 0-7cm	Pilliga 8
	Charcoal slides		
MU 50626	1	Plant opal separated SG 1.7	Oxford Fall
MU 50627	1	Day 2, before treatment	Ecol
MU 50628	1	Day 2, after method 1	Ecol
	Slides for heavy liquid comparisons		
MU 50629	T1	Sodium polytungstate	Pilliga 8
MU 50630	T2	Sodium polytungstate	Pilliga 8
MU 50631	T3	Sodium polytungstate	Pilliga 8
MU 50632	T4	Sodium polytungstate	Pilliga 8
MU 50633	Z1	Zinc Bromide	Pilliga 8
MU 50634	Z2	Zinc Bromide	Pilliga 8
MU 50635	Z3	Zinc Bromide	Pilliga 8
MU 50636	Z4	Zinc Bromide	Pilliga 8

APPENDIX H

PUBLISHED PAPERS

1. Hart, D.M., 1988a. The plant opal content in the vegetation and swamp at Oxford Falls, New South Wales, Australia. *Australian Journal of Botany,* 36: 159-170.

2. Hart, D.M., 1988b. A safe method for the extraction of plant opal from sediments. *Search,* 19: 293-294.

3. Hart, D.M., 1990. Occurrence of the "Cyperaceae-type" Phytolith in Dicotyledons. *Aust. Syst. Bot.,* 3: 745-750.

4. Norris, E.H., Mitchell, P.B. and Hart, D.M., 1991. Vegetation changes in the Pilliga Forests: A preliminary evaluation of the evidence. *In.* A Henderson-Sellers and A.J. Pitman, (Eds). *Vegetation and Climate Interactions in Semi-arid Areas.* Kluwer Academic Publications B V, The Netherlands.

Due to copyright laws, the articles on pages 429-444 of this thesis have been omitted. Please refer to the following citations for the details.

1. Hart, D.H., 1988a. The plant opal content in the vegetation and swamp at Oxford Falls, New South Wales, Australia. *Australian Journal of Botany*, 36: 159-170.

2. Hart, D.M., 1988b. A safe method for the extraction of plant opal from sediments. *Search*, 19: 293-294.

3. Hart, D.M., 1990. Occurrence of the "Cyperaceae-type" Phytolith in Dicotyledons. *Aust. Syst. Bot.,* 3: 745-750.

4. Norris, E.H., Mitchell, P.B. and Hart, D.M., 1991. Vegetation changes in the Pilliga Forests: A preliminary evaluation of the evidence. In. A Henderson-Sellers and A.J. Pitman, (Eds). *Vegetation and Climate Interactions in Semi-arid Areas*. Kluwer Academic Publications B V, The Netherlands.