BOTANICAL STUDIES AT

URBRAE HYGIENE MINING AREA

HUNTLY

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APPENDICES

1. SUMMARY

Seventy-four species were recorded in the Urbrae Hygiene Mining Area. Recordings were taken at regular intervals on a 120m x 120m grid pattern. The results for the tree species, forest stress assessment, logging assessment and soil parameters are summarized in a series of maps at a scale of 1:10000.

Fourteen mapping units were defined and mapped at a scale of 1:5000. In delineating the mapping units, it was possible to subdivide several of the Site-vegetation Types. This subdivision was based upon structural and floristic differences in the plant communities, which were reinforced by corresponding changes in the site conditions.

Stress assessments of the tree species reflected both old and recent deaths in the plant communities at the survey area. These were mapped and should be compared with other studies in the Hygiene Mining Area.

Logging operations were summarized to facilitate the interpretation of structural and floristic differences in the survey area.

Data were presented in a form that could be readily accessible for a future monitoring programme in the Urbrae Hygiene Mining Area.

2. OBJECTIVES

The survey area is located north of the South Dandalup Dam and east of the current Huntly mining operations of Alcoa of Australia Limited. The objective was to provide baseline botanical data for the Urbrae Hygiene Mining Area and in particular to

- survey the Hygiene Mining Area within the boundaries as defined by Alcoa;
- record the vegetation on a grid of 120m x 120m (to tie in with the 15m and 60m pegging intervals); where required (e.g. on sharp boundaries) additional recordings to be taken at the discretion of the field observers;
- rank tree species on abundance scale as defined by Havel (1975a);
- rank all indicator species on abundance scale as defined by Havel (1975a);
- include and record additional perennial species which may assist in future monitoring; selection of these species to be at the discretion of the observers, based upon previous botanical and mapping experience in the Jarrah Forest;
- rank forest stress and logging on a scale of 0 to 5 (e.g. 0 for no forest stress, 5 for "graveyard" forest stress);
- note any obvious features in the soils and landscape which will assist in data interpretation;
- prepare a site-vegetation map at a scale of 1:5000;
- collect, identify and mount plant specimens of species not included in the current collection of Alcoa of Australia Limited.

3. METHODS

An initial reconnaissance was undertaken in conjunction with Alcoa personnel in the Urbrae Hygiene Mining Area at Huntly. Vegetation sampling was carried out in January, 1985. This sampling was based primarily upon recordings at regular intervals on the grid system already established for drilling by Alcoa; additional observations were made along accessible tracks on the boundaries of the survey area (e.g. White Road). Opportunistic collecting was carried out in December, 1984 and January, 1985.

3.1 Flora

Flowering or fruiting species which were not included in Alcoa's current Herbarium at Booragoon were collected from the Urbrae Hygiene Mining Area. The collected specimens were dried, identified and checked with specimens at the Western Australian State Herbarium.

All species currently held in Alcoa's Herbarium were checked for taxonomic name changes (e.g. Trymalium spathulatum is now Trymalium floribundum).

Specimens were mounted, labelled and lodged with Alcoa of Australia Limited at Booragoon.

3.2 Vegetation and Site Assessment

The vegetation was recorded on a grid of 120m x 120m (to tie in with the drilling pegs located at 15m and 60m intervals). Where required (for example, on sharp community boundaries), additional recordings were taken. Information was recorded for a total of 296 sites in the survey area. All data were recorded directly on computer coding forms to expedite data interpretation. During the survey work, additional notes were made on obvious changes in vegetation and site conditions. Data collected at each site included the parameters discussed in the following sections.

3.2.1 Rating of Trees
(based on an abundance scale as defined by Havel, 1975a).

The rating of each tree species was recorded for an area of 20 metres radius from the observation point, according to the following scale:

0 absent;
1 one or two trees;
2 three to five trees;
3 more than five trees, but contributing less than one third of total stand;
4 between one third and one half of total tree stand;
5 more than one half of total stand.

The tree species recorded in the survey area are summarized in the following table (Table 1).

TABLE 1

List of Tree Species Recorded in the Survey Area

Allocasuarina fraseriana (formerly known as Casuarina fraserana)	Sheoak
Banksia grandis	Bull Banksia
Banksia littoralis	Swamp Banksia
Eucalyptus calophylla	Marri
Eucalyptus marginata	Jarrah
Eucalyptus megacarpa	Bullich
Eucalyptus patens	Yarri
Melaleuca preissiana	Paperbark
Persoonia elliptica	
Persoonia longifolia	Snottygobble
Xylomelum occidentale	Woody Pear

3.2.2 Rating of Plant Species
(based on an abundance scale as defined by Havel, 1975a).

The rating of undergrowth species was based upon an area of 5 metres radius from the observation point, using the following scale:

0 absent;
1 very rare; seen only after a careful search;
2 present and observable, but in small numbers only;
3 common locally, but not uniformly over the whole area;
4 common over the whole area;
5 completely dominating undergrowth.

The undergrowth species recorded in the survey area are summarized in the following table (Table 2).

TABLE 2

List of Undergrowth Species Recorded in the Survey Area

* Denotes indicator species defined by Havel (1975a). The remaining indicator species as defined by Havel (1975a) were followed in the field, but are not listed below because they were absent from the survey area.

Acacia divergens	Hemigenia pritzellii
Acacia drummondii	Hibbertia amplexicaulis
* Acacia extensa	Hibbertia aff. gracilipes
Acacia lateriticola	Hibbertia perfoliata
Acacia preissiana	Hibbertia sp.
Acacia pulchella	(formerly H. montana)
Acacia semitrullata	* Hovea chorizemifolia
* Acacia urophylla	Hypocalymma cordifolium
* Adenanthos barbigerus	* Kennedia coccinea
* Agonis linearifolia	Kennedia prostrata
* Astartea fascicularis	* Lasiopetalum floribundum
Astroloma ciliatum	Lechenaultia biloba
Astroloma pallidum	* Lepidosperma angustatum
Boronia crenulata	Lepidosperma tenue
var. gracilis	Lepidosperma sp.
Boronia fastigiata	* Lepidosperma tetraquetrum
Boronia molloyae	* Leptocarpus scariosus
* Bossiaea aquifolium	* Leptomeria cunninghamii
Bossiaea ornata	* Leucopogon capitellatus
Callistemon speciosus	* Leucopogon oxycedrus
* Clematis pubescens	* Leucopogon propinquus
Cyathochaeta avenacea	* Leucopogon verticillatus
Daviesia cordata	* Macrozamia riedlei
* Daviesia decurrens	Mirbelia dilatata
Daviesia incrassata	* Phyllanthus calycinus
Daviesia preissii	* Pteridium aquilinum
Daviesia rhombifolia	Sphaerolobium medium
Gahnia decomposita	Stachystemon vermicularis
Hakea amplexicaulis	* Styphelia tenuiflora
* Hakea lissocarpha	Thomasia paniculata
* Hakea ruscifolia	* Trymalium ledifolium
Hakea undulata	Xanthorrhoea gracilis
	Xanthorrhoea priessii

Tree and undergrowth species were recorded in smaller areas than those recorded by Havel (1975a); he used an area of 40m radius for trees and 20m radius for undergrowth species. Previous mapping of the Jarrah forest has indicated that the smaller sizes are appropriate for following the tree and undergrowth species (based on species/area curves and regular observation points).

3.2.3 Site Assessment

3.2.3.1 Soil Colour

The soil colour was recorded as a series of presence/absence (binary or yes/no) data items. The colours recorded were Dark Brown, Brown, Light Brown, Orange, Red, Yellow and Grey. These colours were recorded for soil depths of 10 to 20 cms.

3.2.3.2 Gravel Size

Average gravel fragment diameters were recorded for all sites. The diameter intervals were:

-5mm
+5mm -10mm
+10mm

3.2.3.3 Gravel Colour

Recent observations in the western Jarrah forest have highlighted the need to differentiate darker gravels from the more typical orange lateritic gravel. Therefore the colour of the surface gravel was recorded as either "orange-brown" or "black".

3.2.3.4 Gravel:Sand:Silt Ratio

The proportions of gravel, sand and silt in the soil matrix at a depth of 10 to 20 cms were recorded relative to a total score of ten (e.g. a heavy gravel with a sandy matrix would be recorded as 7:3:0; while a sandy-loam with limited gravel component would be recorded as 2:4:4).

3.2.3.5 Presence of Boulders and Outcropping

The presence of lateritic boulders or outcrops (granitic or lateritic) was recorded at each site.

3.2.3.6 Slope

The slope in a direction forward along the survey transects was recorded using a Sunto Clinometer, in positive or negative degrees. Additional slope angles were measured when considered appropriate (e.g. sharp slope changes at an angle from the transect's orientation).

3.2.3.7 Position in the Landscape

To assist in the interpretation of field observations, the landscape was subdivided into the following categories; Upper Slope, Mid/Upper Slope, Mid Slope, Mid/Lower Slope, Lower Slope, Gully and Ridge.

3.2.3.8 Drainage Patterns

To assist in the interpretation of the results, the drainage patterns were subdivided into the following four categories; Convex, Concave, Level and Slope.

3.3 Forest Stress Assessment

Although the causes of forest stress are varied, their expression in a plant community is usually in the form of discolouration of leaves, defoliation and death. The following rating of forest stress has been developed and tested in other areas of the northern Jarrah forest, and was used in this survey.

For each tree species in an area of 20 metre radius from the observation point, the stress was recorded using the scale:

0 no evidence of stress in plants;
1 odd plant showing signs of stress, none dead;
2 one or two stressed plants, usually under severe stress and near death (but not dead);
3 scattered stressed and dead plants around plot;
4 susceptible plants dying or dead;
5 "Graveyard" death; most trees logged or salvaged.

A further subdivision of stress levels greater than 3 was made by including the following assessment of the age since death and separation of "stag" deaths from deaths caused by other factors:

O Old deaths (no leaves left on trees);
R Recent deaths (leaves only recently dessicated or discoloured);
S Old stag deaths.

3.4 Logging Assessment

Previous logging impacts on the forest structure and composition were assessed at each observation point in the survey area. The number and age of the stumps were used to rate the logging by observing each tree species in an area of 20 metres radius from the point of observation, and recording the rate relative to the following scale:

0 no evidence of logging (absence of stumps);
1 very old loggings; one cut only (age of stumps all old);
2 recent logging only (light logging rate, less than three stumps in the area of observation);
3 old and recent logging; area cut over twice at a light rate (less than three stumps in each age of cutting);
4 logged intensively; heavy logging rate (more than three stumps for each age of logging in the area);

5 "Graveyard" or salvage logging.

3.5 Site-vegetation Map

The site-vegetation map was prepared from an interpretation of the reconnaissance and survey data. All tree and undergrowth species used by Havel (1975 a and b) were assessed for abundance and reliability in reflecting site conditions at the Urbrae Hygiene Mining Area. Previous findings in the northern Jarrah forest suggest that several of the indicator species are more reliable in different areas of the forest. This fact largely relates to the differing distributions of the plant species concerned; e.g. a species on the limits of its geographical range will be more site selective than in the centre of its range. Other perennial species which occurred in the survey area were recorded to assist in the site-vegetation mapping and to provide a basis for planning a monitoring programme. In instances where these additional species were site specific, they were included in the data interpretation for the site-vegetation map.

A draft site-vegetation map at a scale of 1:5000 was then prepared on the basis of the following parameters:

- the distribution of each indicator species (Havel, 1975 a and b);
- the distribution of non-indicator species, particularly those which illlustrated a regularity in their occurrence;
- the structural differences in the plant communities in the survey area (e.g. heath, open forest, woodland);
- the distribution of the Indicator Groups as defined by Havel (1975 a and b).

During the preparation of the site-vegetation map, the objectives of the Urbrae Hygiene Mining Area were considered. As a consequence, emphasis was placed on assisting the interpretation of hygiene and commmunity susceptibilities to the dieback disease (Phytophthora cinnamomi).

This emphasis stressed the need to concentrate on the Indicator Groups as well as the Site-vegetation Types as defined by Havel (1975 a and b). For example, the variation in the Site-vegetation Type S was reviewed and assessed in relation to the variation in community vulnerability to infection.

The draft site-vegetation map was refined and checked against the various site parameters recorded at each observation point. If this necessitated an alteration to the site-vegetation boundaries, then the floristic and structural data was rechecked for observation points in proximity to the area under review. The following site conditions were reviewed:

- soil colour,
- gravel size,
- gravel colour,
- gravel:sand:silt ratio,
- presence of boulders and exposed outcropping or caprock,
- slope,
- aspect,
- position in the landscape, and
- drainage patterns.

Additional checking of the boundaries was carried out by comparing the draft site-vegetation map with a topographic contour map and an aerial photograph, both supplied by Alcoa and both at a scale of 1:5000. Several minor alterations were made to the boundaries in the gullies (on the fringes of the survey area) and in areas between transect lines.

4. RESULTS

4.1 Flora

A total of 21 Families and 74 Species were recorded during the botanical studies on the Urbrae Hygiene Mining Area (Appendix E). Additional indicator species as defined by Havel (1975 a and b) were noted during the survey, but were not included in the list as they were not observed during the survey.

No attempt was made to list all of the species present in the survey area. As the survey was carried out in December and January, the number of flowering species was restricted. Therefore only those species which were flowering or fruiting were considered for submission to Alcoa's herbarium. These specimens were processed and submitted to the Company on completion of the field work.

4.2 Vegetation and Site Assessment

4.2.1 Tree Species Ratings

The results for each tree species are summarized in Appendix A.

Allocasuarina fraseriana (Appendix A1)
Sheoak occurred on the mid and upper slopes of the main ridge which runs north-west to south-east. Sheoak occurred with Eucaltyptus marginata, Banksia grandis and Persoonia longifolia. Adenanthos barbigerus occurred in the understorey of the Sheoak communities on the northern less undulating slopes.

Banksia grandis (Appendix A2)
Bull Banksia occurred in the majority of the survey area, but tended to avoid the sandy-loam soils on the lower slopes and in the gullies. Abundance levels were higher on the mid and upper slopes of the main ridges. The latter can be seen by separating rating levels of greater or equal to 4 from those less than 4. The large numbers of Bull Banksia in the survey

area require attention in light of their recognized ability to host the fungus Phytophthora cinnamomi.

Banksia littoralis (Appendix A3)
Swamp Banksia occurred on the fringes of the survey area in the swamps, creek-beds and moister lower slopes. This species is also known to be susceptible to the fungus Phytophthora cinnamomi and therefore its presence in gullies could be used to assist in monitoring hygiene techniques.

Eucalyptus calophylla (Appendix A4)
Marri occurred over the majority of the survey area, but varied in its abundance. Higher ratings were recorded on the lower slopes and in the side-gullies to the north. The latter appeared to relate to the higher sand and silt components of the soils in these areas. This species tended to avoid the drier sandy-gravels and rocky areas of the upper slopes and ridges.

Eucalyptus marginata (Appendix A5)
Jarrah occurred in the majority of the survey area. The rating method used in this survey did not include basal areas or numbers of stems and so the denser pole stands on the northern slopes were not delineated. However observations along the transects compensated for this gap in information. Jarrah tended to avoid the moister lower slopes and gullies.

Eucalyptus megacarpa (Appendix A6)
Bullich occurred in the gullies (particularly the well-drained creek-beds) and the lower slopes. As such, it overlapped the Yarri and Jarrah distributions. In some areas, Bullich occurred up-slope with Jarrah and in a few areas with Sheoak.

Eucalyptus patens (Appendix A7)
Yarri occurred on the lower moist slopes in the main gullies of the survey area. In fact, Yarri tended to form a narrow fringing band near the swamps and creek-beds.

Persoonia elliptica (Appendix A8)
This species occurred on the sandy-gravels and gravelly soils of the upper slopes and ridges of the survey area. The abundance levels were relatively low (usually less than or equal to 2).

Persoonia longifolia (Appendix A9)
Snottygobble occurred on the majority of the mid and upper slopes of the survey area. This species, like Bull Banksia, tended to avoid the lower slopes and gullies.

Melaleuca preissiana (Appendix A10)
Paperbark occurred on the broad wetter swamp areas in the gullies fringing the survey area.

Xylomelum occidentale
This species occurred in localized patches on the lower slopes with sandy soils. This species is relatively restricted in occurrence in the northern Jarrah forest and consequently was not included in Havel's studies. Larger populations occur on the coastal plain near Bunbury and south of Collie in the Jarrah forest.

In summary, these tree rating results delineated a series of patterns which were used to prepare the site-vegetation map. All species reflected site preferences in their distribution patterns. The details supplied in Appendix A should assist in monitoring the hygiene programme and other changes associated with mining operations in the Urbrae Hygiene Mining Area.

4.2.2 Undergrowth Species Ratings

The data recorded for the undergrowth species were assessed for each recording site. The following text briefly summarizes the findings concerning the indicator species as defined by Havel (1975 a and b) and also selected perennial species which assisted in the preparation of the site-vegetation map and community descriptions. Only those non-indicator species (not used by Havel) which illustrated clear site preferences were included in this report. The remaining results for the other perennial species have been submitted to the Company for future reference.

The first groups of species are indicator species as defined by Havel in his Indicator Groups and Site-vegetation Types (Havel, 1975a).

Acacia extensa was restricted to several locations on the western and southern lower slopes. This species is an indicator of the group FERMO (FERtile MOist).

Acacia urophylla occurred on the upper gravelly slopes in the north-west and south-east of the survey area. This species is an indicator of the group GRAHIR (GRAvels in HIgh Rainfall).

Adenanthos barbigerus occurred largely in the less undulating sandy-gravels on the northerly aspect of the survey area. This species occurs in the GRAMED (GRAvels in MEDium rainfall areas) group.

Agonis linearifolia occurred in large numbers in the wet gullies and on the valley floors. This species occurs in the WETAL (WET ALluvium) group.

Astartea fascicularis occurred in large numbers in the wet gullies and broad valley floors. This species occurs in the group VERWET (VERy WET sites).

Bossiaea aquifolium occurred on the lower slopes and steeper mid-slopes of the survey area. The denser stands were recorded in the north-west and southern areas. This species occurs in group GRAHIR.

Clematis pubescens occurred on the moister loam soils on the lower and mid slopes in the north and south-west areas. This species appeared to be relatively site-specific with other members of the HIGRA (HIgh rainfall, predominantly GRAvelly soils) group.

Daviesia decurrens (formerly Daviesia pectinata) occurred in the south-east corner of the survey area on the sandy-gravels of the upper gully. This species occurs in the DRYSAG (DRY SAndy Gravels) group.

Hakea lissocarpha occurred in a few localized pockets on the lower slopes in the north of the survey area. This species occurs in the BROFER group (BROad tendency towards higher FERtility)

Hakea ruscifolia occurred in several localized patches on the northern lower slopes and on the sandy-gravelly soils in the south of the survey area. This species is similar to Daviesia decurrens in its grouping (group DRYSAG).

Hovea chorizemifolia occurred on the upper slopes and ridges in the survey area. This species occurs in the GRAMED group.

Kennedia coccinea was relatively restricted in its occurrence in the survey area. Minor patches were recorded in the north-west and south-east corners. Havel (1975a) noted that Kennedia coccinea appeared to have a range comparable with that of Hakea lissocarpha. The results from this survey generally support that observation.

Lasiopetalum floribundum occurred on the lower and mid slopes of the survey area. This species occurs in the GRAHIR group.

Lepidosperma angustatum occurred in only restricted areas on the upper sandy-gravel slopes and as such does not contribute significantly to the separation of Site-vegetation Types and the mapping. This species occurs in the BROMO (BROad MOist areas) group.

Lepidosperma tetraquetrum occurred on the wet valley floors. This species occurs in the WETAL group.

Leptocarpus scariosus occurred on the moister lower slopes in the north and south. This species occurs in the BROWET (BROad tendency towards WET sites) group.

Leptomeria cunninghamii did not occur in sufficient areas or in large numbers to warrant further investigation in this survey.

Leucopogon capitellatus and Leucopogon propinquus occurred over the majority of the area on gravelly soils. These species occur in the FREGRA (FREsh GRAvels with maximum development on admixture of lateritic gravels and fresh soils developed from underlying rocks) group.

Leucopogon oxycedrus occurred in relatively low numbers, but consistently on the sandy gravels and gravels of the mid and upper slopes.

Leucopogon verticillatus occurred in large numbers over the majority of the survey area. However it tended to avoid the lower slopes and gullies. In this regard it differed from its other HIGRA species by being less site-specific in its occurrence.

Macrozamia riedlei occurred throughout the survey area, although in larger numbers on the northern slopes. This distribution differed from that of other members of the FREGRA group. In this instance, numbers appear to be more important than presence of a particular species.

Phyllanthus calycinus occurred over the majority of the slopes with gravelly soils. This species occurs in the FREGRA group.

Pteridium aquilinum (Bracken) occurred on the moister gravelly soils. Its distribution was similar to that of Clematis pubescens, but was not as widespread as Leucopogon verticillatus of the same HIGRA group.

Sphaerolobium medium occurred in minor patches and did not contribute to the understanding of species groupings.

Styphelia tenuiflora occurred on the sandy-gravels of the south-east and northern lower slopes. This species occurs in the DRYGRA (DRY GRAvels) group.

Trymalium ledifolium occurred on the majority of gravelly slopes. The distribution was similar to that of Phyllanthus calycinus.

The majority of these indicator species assisted in delineating the distribution of the Indicator Groups and the Site-vegetation Types in the Urbrae Hygiene Mining Area.

Other species recorded also showed clear-cut site preferences and were consequently used in the delineation of the mapping units. They were

Boronia crenulata var. gracilis was restricted to moist lower slopes supporting an open forest of Bullich.

Boronia molloyae was restricted to creek-beds and wet valley floors.

Callistemon speciosus was restricted to wet valley floors.

Daviesia rhombifolia was restricted to drier sandy-gravels supporting a woodland of Jarrah-Marri.

Gahnia decomposita was restricted to wet valley floors and creek-beds.

Hypocalymma cordifolium was restricted to wet valley floors and creek-beds.

Mirbelia dilatata was restricted to lower moist slopes supporting an open forest of Marri-Jarrah with some admixtures of Bullich.

Xanthorrhoea preissii was widespread in occurrence, with larger numbers recorded on the lower slopes and steeper mid-slopes.

4.2.3 Forest Stress Assessment

Results are summarized for the four tree species which are recognized as being vulnerable to the fungus disease Phytophthora cinnamomi (Appendix B). Stress was also observed in Xanthorrhoea preissii and Macrozamia riedlei.

Results for the four tree species were:

Banksia grandis stands displayed old and recent stress. The majority of the deaths were old (with no signs of recent discolouration or loss of leaves). Recent deaths were recorded predominantly near tracks in the western and southern sections of the survey area. Additional observations near the tracks indicated that the areas of recent stress illustrated on the maps were more extensive than suggested by the transecting on the 120m x 120 grid system.

Banksia littoralis stands were relatively healthy, with only one old death being observed on the transecting.

Eucalyptus marginata stands were relatively stressed throughout the survey area; stress ratings tended to be 1 or 2 in most areas. Where deaths had occurred, they were mostly old and many related to age ("stag" deaths). Additional observations recorded several recent deaths on the lower slopes in the south-west corner of the survey area. This pattern was also noted in the Bull Banksia.

Persoonia longifolia stands were relatively healthy, as only a limited number of deaths were recorded in the survey area.

Results for the other tree species reflected some slight stress (levels usually 1), except where old "stags" of Marri were recorded.

In summary, the stress levels evident in the forest areas indicated that there were localized patches of recent deaths. These areas require checking with other studies in the area.

4.2.4 Site Assessment

The results for the site assessment parameters are summarized in Appendix C.

Several of the parameters were not mapped, but were used in the checking of the draft site-vegetation map. These parameters included the gravel size, gravel colour (no

black gravel was recorded in the survey area), slope, aspect, topographic position and drainage patterns. Relationships with these site conditions are evident from the site preferences of the different plant species (e.g. Agonis linearifolia occurred in the wet broad valley floors; section 4.2.2).

Soil Colours (Appendix C1) reflected the degree of leaching and weathering processes. The main trends included the orange soils on the upper slopes, light brown soils in the gullies and on the lower slopes, brown soils on the slopes and yellow and grey soils on the lower slopes and valley floors.

Soil Composition (Appendices C2, C3 and C4) recordings reflected the transition from gravelly soil on the upper slopes, through sandy-gravels on the mid and upper slopes to silts and loams in the side-gullies and on the lower slopes.

Boulders and Outcropping (Appendix C5) observations showed that the boulders occurred mainly on the upper slopes and ridges, while the shallow outcrops and caprock were restricted to the ridges in the survey area.

These results were used in checking the draft site-vegetation map. The site conditions assisted in delineating and clarifying the map boundaries.

4.2.5 Logging Assessment

The results for past logging activities are summarized in Appendix D.

Results indicated that the early logging activities in the area were extensive (though not intensive) over the majority of the survey area. Predictably, logging rates were low near the swamps and lower slopes. Recent logging activities have been concentrated in the southern areas near the main access tracks. The impact of logging tracks and logging activities is particularly evident on the aerial photographs of this southern section. The logging activities appear to correspond to several of the Site-vegetation Types (e.g. D, P-D, P-S2 and S2). Previous logging activities may have affected the current

floristic composition of the plant communities. The latter was taken into consideration when assessing the structural and floristic differences in the survey area.

4.3 Site-vegetation Map

All the results summarized in the previous sections were reviewed and summarized by Indicator Group and Site-vegetation Types for the delineation of the mapping units (Table 3).

TABLE 3

Summary of Indicator Groups and Site-vegetation Types in the Urbrae Hygiene Mining Area

	Indicator Groups										
Site-vegetation Types	WETAL	VERWET	FERMO	BROWET	GRAHIR	HIGRA	DRYSAG	FREGRA	GRAMED	SANGRA	DRYGRA
A-C	+	+									
C	+	+	+								
A-W1		+	+	+			+				
W1	+		+		+						
W2	+				+	+		+			
T1					+	+		+			
T2					+	+		+	+		
P-S1					+	+		+	+	+	
P-S2						+		+	+	+	+
S2						+		+	+		
S1-P								+	+	+	+
S1								+	+		+
P-O							+	+	+	+	+
O							+	+	+		+

These Site-vegetation Types were mapped at a scale of 1:5000 for the Urbrae Hygiene Mining Area. The mapping units were:

A-C Closed Heath and Low Open Woodland of Melaleuca preissiana, Banksia littoralis. Understorey species dominated by Agonis linearifolia, and Astartea fascicularis.
Indicator Groups: VERWET and WETAL.

C Open woodland of Eucalyptus patens-E. megacarpa with admixtures of Banksia littoralis. Understorey species include Thomasia paniculata, Lepidosperma tetraquetrum, Agonis linearifolia and Hypocalymma cordifolium.
Indicator Groups: WETAL, VERWET, FERMO.

A-W1 Open forest of Eucalyptus marginata-E. calophylla with some admixtures of E. patens. Other dominant species include Banksia littoralis and Xylomelum occidentale, Leptocarpus scariosus, Xanthorrhoea preissii and Hakea ruscifolia.
Indicator Groups: VERWET, FERMO, BROWET, DRYSAG.

W1 Open forest of Eucalyptus patens-E. megacarpa. Understorey species include Boronia crenulata var.gracilis, Lasiopetalum floribundum and Xanthorrhoea preissii.
Indicator Groups: WETAL, FERMO, GRAHIR.

W2 Open forest of Eucalyptus megacarpa-E. calophylla and E. marginata. Understorey species dominated by Xanthorrhoea preissii, Lasiopetalum floribundum and Bossiaea aquifolium.
Indicator Groups: WETAL, GRAHIR, HIGRA, FREGRA.

T1 Open forest of Eucalyptus calophylla-E. marginata. Understorey species dominated by Bossiaea aquifolium, Lasiopetalum floribundum, Macrozamia riedlei, Pteridium aquilinum and Xanthorrhoea preissii.
Indicator Groups: GRAHIR, HIGRA, FREGRA.

T2 Open forest of Eucalyptus marginata-E. calophylla with occasional admixtures of Banksia grandis and Persoonia longifolia. Understorey species dominated by Phyllanthus calycinus, Pteridium aquilinum, Acacia urophylla, Lasiopetalum floribundum, Hovea chorizemifolia and Clematis pubescens.
Indicator Groups: GRAHIR, HIGRA, FREGRA, GRAMED.

P-S1 Open forest of Eucalyptus marginata-E. calophylla, with admixtures of Allocasuarina fraseriana, Banksia grandis and Persoonia longifolia. Understorey species dominated by Hovea chorizemifolia, Adenanthos barbigerus, Phyllanthus calycinus ,Leucopogon verticillatus and Lasiopetalum floribundum.
Indicator Groups: largely SANGRA, FREGRA, GRAMED, to a lesser extent HIGRA and GRAHIR.

P-S2 Open forest of Eucalyptus marginata-E. calophylla with admixtures of Allocasuarina fraseriana, Banksia grandis and Persoonia longifolia. Understorey species include Hovea chorizemifolia, Leucopogon capitellatus, Leucopogon verticillatus, Phyllanthus calycinus and Styphelia tenuiflora.
Indicator Groups: largely SANGRA, FREGRA, GRAMED, to a lesser extent HIGRA and DRYGRA.

S2 Open forest of Eucalyptus marginata-E. calophylla with admixtures of Banksia grandis and Persoonia longifolia. Understorey species include Leucopogon capitellatus, Leucopogon propinquus, Leucopogon verticillatus, Hovea chorizemifolia and patches of Pteridium aquilinum.
Indicator Groups: largely GRAMED, FREGRA, to a lesser extent HIGRA.

Sl-P Open forest of Eucalyptus marginata-E. calophylla, with admixtures of Banksia grandis and the occassional occurrence of Allocasuarina fraseriana. Understorey species dominated by Adenanthos barbigerus, Phyllanthus calycinus and Leucopogon verticilllatus. In floristic composition it is similar to P-Sl, but differs in the minor occurrence of Sheoak.
Indicator Groups: largely FREGRA, GRAMED, to a lesser extent DRYGRA and SANGRA.

Sl Open forest of Eucalyptus marginata-E. calophylla with admixtures of Banksia grandis and Persoonia longifolia. Understorey species dominated by Adenanthos barbigerus, Leucopogon capitellatus, Hovea chorizemifolia and Phyllanthus calycinus.
Indicator Groups: largely FREGRA, GRAMED, to lesser extent DRYGRA.

P-O Open woodland and open forest of Eucalyptus marginata-E. calophylla, with admixtures of Allocasuarina fraseriana and Banksia grandis. Understorey species dominated by Daviesia decurrens, Hakea ruscifolia, Trymalium ledifolium, Phyllanthus calycinus and Styphelia tenuiflora.
Indicator Groups: SANGRA, DRYSAG, DRYGRA, FREGRA, GRAMED.

O Open woodland of Eucalyptus marginata-E. calophylla, with some admixtures of Persoonia longifolia and Banksia grandis. Understorey species dominated by Daviesia decurrens, Hakea ruscifolia, Trymalium ledifolium, Phyllanthus calycinus and Styphelia tenuiflora.
Indicator Groups: DRYSAG, DRYGRA, FREGRA, GRAMED.

5. DISCUSSION AND CONCLUSIONS

In view of the objectives of the botanical studies on the Urbrae Hygiene Mining Area, an emphasis was placed on delineating mapping units which would assist in summarizing the plant communities and site conditions in the survey area as well as providing a baseline for future management programmes associated with the hygiene mining operation. Consequently, the Site-vegetation Types were grouped to reflect underlying structural and floristic differences in the plant communities. In each case, these differences were checked with existing site conditions.

Some of the mapping units were clear-cut. The most obvious was the heaths in the swamp communities. Site-vegetation Types A-C and C were clearly differentiated on both the distinct range of species and the underlying soil conditions. The A-C type differs in floristic composition from the eastern A swamp type as defined by Havel (1975a), with the dominance of the shrubs, Agonis linearifolia and Astartea fascicularis. The W1 and W2 distinction was based primarily upon the differences in the overstorey (W1, an open forest of Yarri-Bullich; W2, an open forest of Bullich-Marri-Jarrah). This division was supported by differences in understorey species and site conditions. A - W1 was a local variation with very distinctive species composition, (Banksia littoralis, Eucalyptus marginata and Xylomelum occidentale). This separation was further clarified by recordings on the understorey species and the site conditions (sandy soils which were subject to seasonal moisture as reflected by Leptocarpus scariosus).

The Site-vegetation Types O and W differed from the description of these types by Havel (1975a and b) by varying degrees, either through logging in the case of O or through the changes in floristic composition in W (e.g. Bullich upslope with Jarrah). Irrespective of these differences, when compared with Havel's descriptions they had closer affinities with these types than others.

The Site-vegetation Types T1 and T2 were split initially on their different overstorey composition (T1, an open forest of Marri-Jarrah; T2, an open forest of Jarrah-Marri with admixtures of Bull Banksia). Other differences in the understorey composition later confirmed the need to separate these mapping units. T1 had affinities with Site-vegetation Type T as defined by Havel (1975a); while T2 had affinities with a mixture of T and S types (whether a T-S or S-T type depends on the interpreter's weighting of the indicator species). Further a review of the soils and site conditions added to the justification (e.g. higher gravel component in T2).

Similar differences were recorded in the P-S1, P-S2, S1 and S2 divisions. The P influence related to the high occurrence of Sheoak and hence sandy-gravels; S1 was related to the presence of Adenanthos barbigerus and the sandy gravelly soils while S2 was related to the dominance of Jarrah and Bull Banksia on the shallow soils on the ridges and upper slopes. In all instances, these mapping units and varying combinations were reinforced by other undestorey species and site parameters. Other studies in the Jarrah forest have reinforced the need to clarify the differing vulnerability of the Indicator Groups in the different Site-vegetation Types to disease and other impacts.

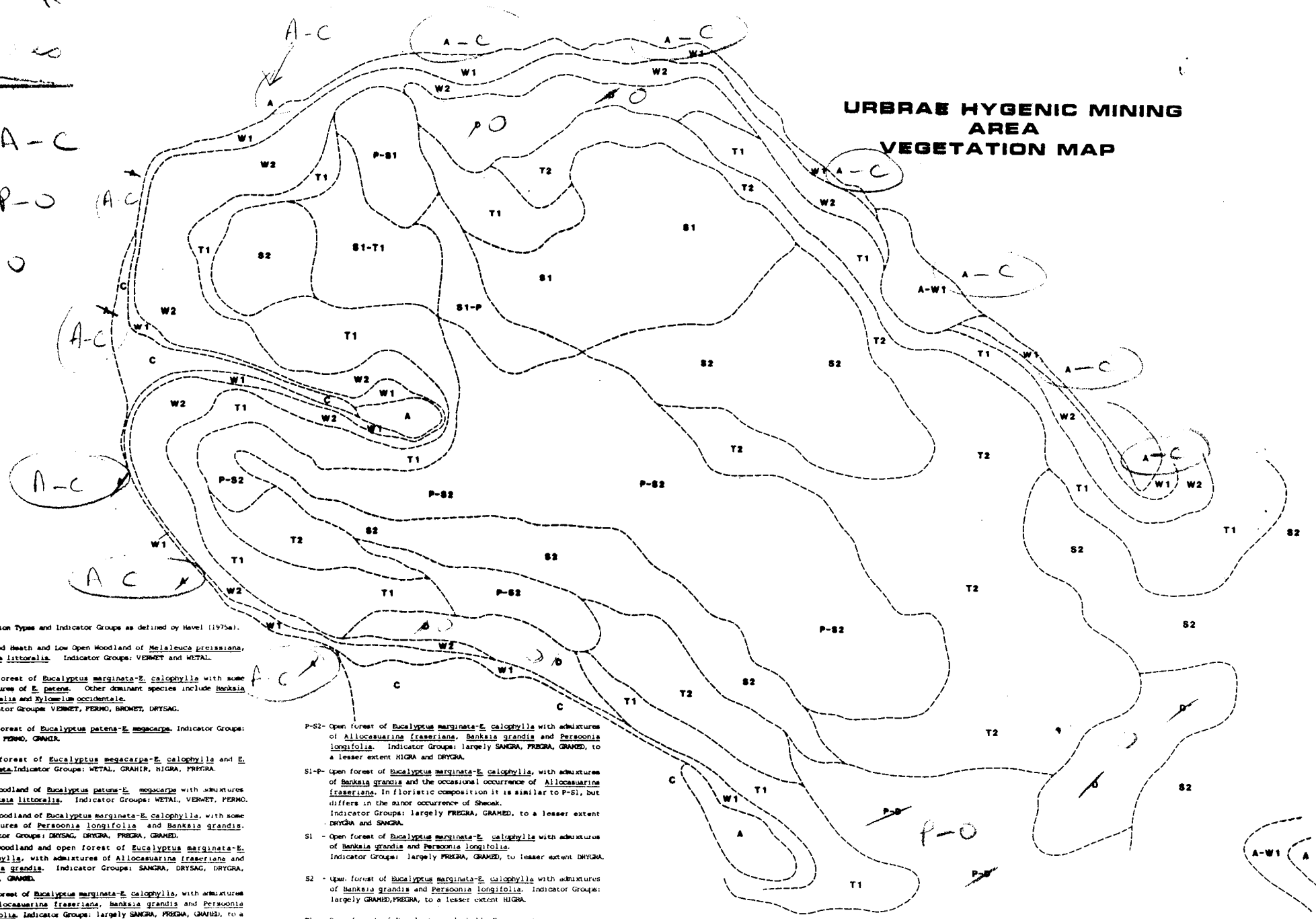
In summary, it was possible to subdivide the Site-vegetation Types into a series of mapping units which may assist in future monitoring of the impacts associated with bauxite mining operations. Although many of these differences were subtle, they were all validated by structural and floristic differences, which were in turn reinforced by changes in the site conditions.

6. REFERENCES

Havel, J.J. (1975 a) "Site-vegetation Mapping in the Northern Jarrah Forest (Darling Range). 1. Definition of Site-vegetation Types." Forests Department Bulletin No. 86., Forests Department, Perth, Western Australia.

Havel, J.J. (1975 b) "Site-vegetation Mapping in the Northern Jarrah Forest (Darling Range). 2. Location and Mapping of Site-Vegetation Types." Forests Department Bulletin No. 87., Forests Department, Perth, Western Australia.

URBRAE HYGENIC MINING AREA VEGETATION MAP



Site-Vegetation Types and Indicator Groups as defined by Havel (1975a).

A - Closed Heath and Low Open Woodland of Melaleuca preissiana, Banksia littoralis. Indicator Groups: VERWET and WETAL.

A-WO- Open forest of Eucalyptus marginata-E. calophylla with some admixtures of E. patens. Other dominant species include Banksia littoralis and Xylomelum occidentale.
Indicator Groups: VERWET, PERMO, BROWET, DRYSAG.

W1 - Open forest of Eucalyptus patens-E. megacarpa. Indicator Groups: WETAL, PERMO, GRAHIR.

W2 - Open forest of Eucalyptus megacarpa-E. calophylla and E. marginata.Indicator Groups: WETAL, GRAHIR, HIGRA, PREGRA.

C - Open woodland of Eucalyptus patens-E. megacarpa with admixtures of Banksia littoralis. Indicator Groups: WETAL, VERWET, PERMO.

O - Open woodland of Eucalyptus marginata-E. calophylla, with some admixtures of Persoonia longifolia and Banksia grandis. Indicator Groups: DRYSAG, DRYGRA, PREGRA, GRAMED.

P-O - Open woodland and open forest of Eucalyptus marginata-E. calophylla, with admixtures of Allocasuarina fraseriana and Banksia grandis. Indicator Groups: SANGRA, DRYSAG, DRYGRA, PREGRA, GRAMED.

P-S1- Open forest of Eucalyptus marginata-E. calophylla, with admixtures of Allocasuarina fraseriana, Banksia grandis and Persoonia longifolia. Indicator Groups: largely SANGRA, PREGRA, GRAMED, to a lesser extent HIGRA and GRAHIR.

P-S2- Open forest of Eucalyptus marginata-E. calophylla with admixtures of Allocasuarina fraseriana, Banksia grandis and Persoonia longifolia. Indicator Groups: largely SANGRA, PREGRA, GRAMED, to a lesser extent HIGRA and DRYGRA.

S1-P- Open forest of Eucalyptus marginata-E. calophylla, with admixtures of Banksia grandis and the occasional occurrence of Allocasuarina fraseriana. In floristic composition it is similar to P-S1, but differs in the minor occurrence of Sheoak.
Indicator Groups: largely PREGRA, GRAMED, to a lesser extent DRYGRA and SANGRA.

S1 - Open forest of Eucalyptus marginata-E. calophylla with admixtures of Banksia grandis and Persoonia longifolia.
Indicator Groups: largely PREGRA, GRAMED, to lesser extent DRYGRA.

S2 - Open forest of Eucalyptus marginata-E. calophylla with admixtures of Banksia grandis and Persoonia longifolia. Indicator Groups: largely GRAMED,PREGRA, to a lesser extent HIGRA.

T1 - Open forest of Eucalyptus calophylla-E. marginata.
Indicator Groups: GRAHIR, HIGRA, PREGRA.

T2 - Open forest of Eucalyptus marginata-E. calophylla with occassional admixtures of Banksia grandis and Persoonia longifolia. Indicator Groups: GRAHIR, HIGRA, PREGRA, GRAMED.

BOTANICAL STUDIES AT

URBRAE HYGIENE MINING AREA

HUNTLY

APPENDICES

APPENDIX A

BOTANICAL STUDIES AT URBRAE HYGIENE MINING AREA

RATING OF TREES ON AN ABUNDANCE SCALE OF 0-5

A1 - Rating of Trees - Allocasuarina fraseriana

A2 - Rating of Trees - Banksia grandis

A3 - Rating of Trees - Banksia littoralis

A4 - Rating of Trees - Eucalyptus calophylla

A5 - Rating of Trees - Eucalyptus marginata

A6 - Rating of Trees - Eucalyptus megacarpa

A7 - Rating of Trees - Eucalyptus patens

A8 - Rating of Trees - Persoonia elliptica

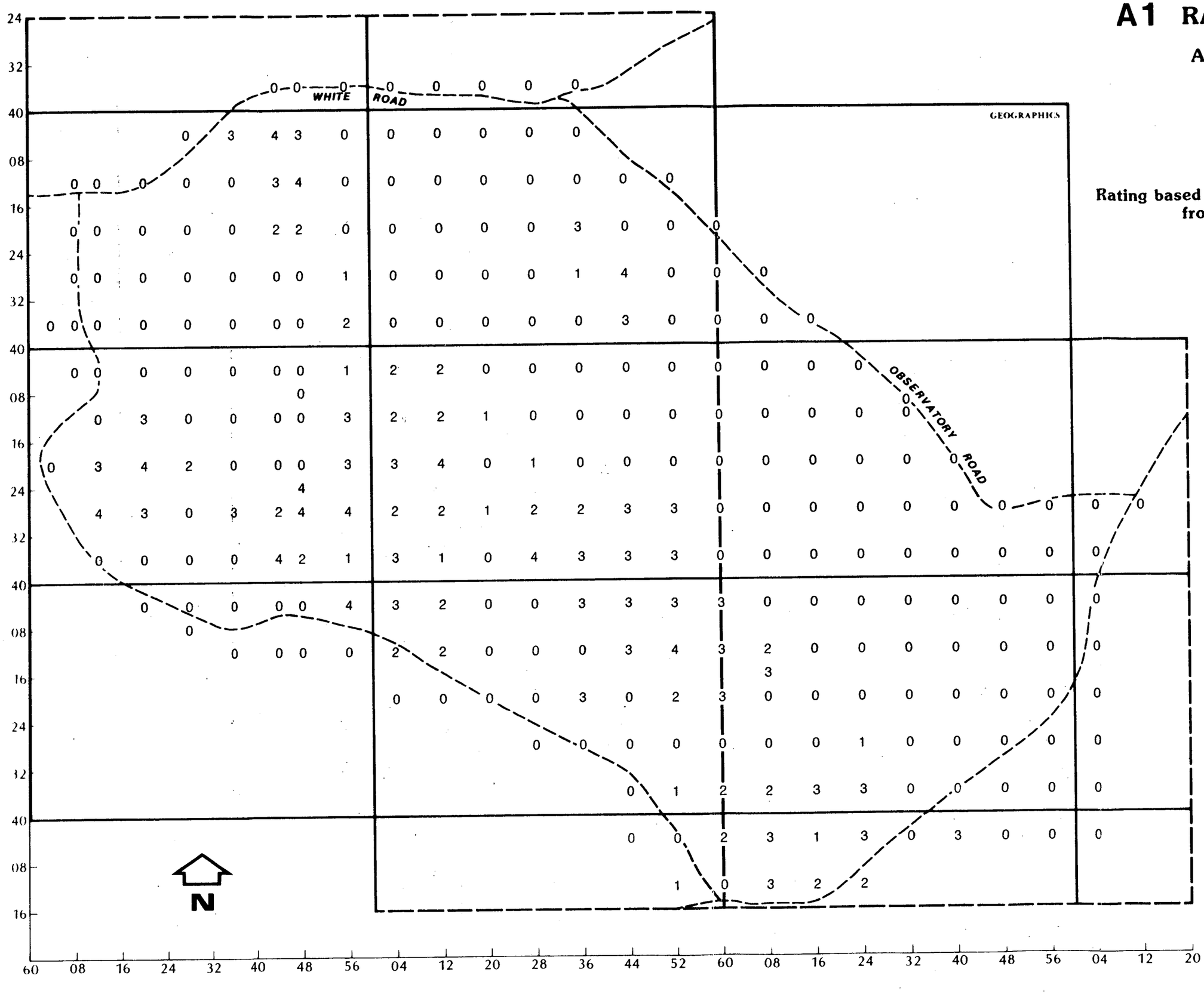
A9 - Rating of Trees - Persoonia longifolia

A10- Rating of Trees - Melaleuca preissiana

A1 RATING OF TREES

Allocasuarina fraseriana

Rating based on an area of 20m radius from centre of recording site



0 Absent

1 One or two trees

2 Three to five trees

3 More than five trees, but contributing less than one third of total stand

4 Between one third and one half of total stand

5 More than one half of total stand

SCALE 1:10 000

F4528	G4525		
F4604	G4601	G4602	
F4608	G4605	G4606	G4607
F4612	G4609	G4610	G4611
	G4613	G4614	G4615

A2 RATING OF TREES

Banksia grandis

WHITE ROAD

OBSERVATORY ROAD

GEOGRAPHICS

Rating based on an area of 20m radius from centre of recording site

0 Absent

1 One or two trees

2 Three to five trees

3 More than five trees, but contributing less than one third of total stand

4 Between one third and one half of total stand

5 More than one half of total stand

SCALE 1:10 000

F4528	G4525		
F4604	G4601	G4602	
F4608	G4605	G4606	G4607
F4612	G4609	G4610	G4611
	G4613	G4614	G4615

A3 RATING OF TREES

Banksia littoralis

Rating based on an area of 20m radius from centre of recording site

0 Absent

1 One or two trees

2 Three to five trees

3 More than five trees, but contributing less than one third of total stand

4 Between one third and one half of total stand

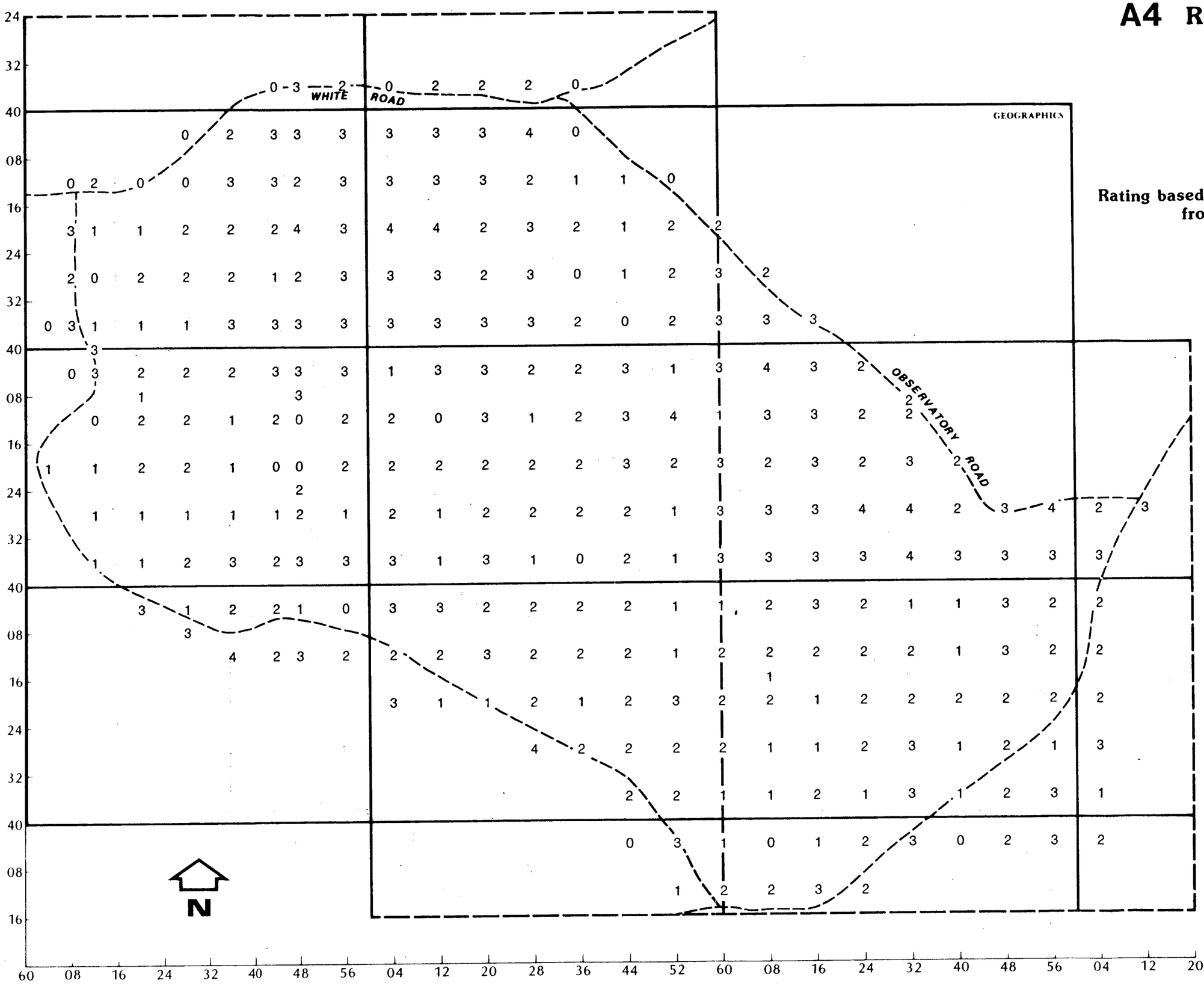
5 More than one half of total stand

SCALE 1:10 000

F4528	G4525		
F4604	G4601	G4602	
F4608	G4605	G4606	G4607
F4612	G4609	G4610	G4611
	G4613	G4614	G4615

A4 RATING OF TREES

Eucalyptus calophylla



Rating based on an area of 20m radius from centre of recording site

0 **Absent**

1 **One or two trees**

2 **Three to five trees**

3 **More than five trees, but contributing less than one third of total stand**

4 **Between one third and one half of total stand**

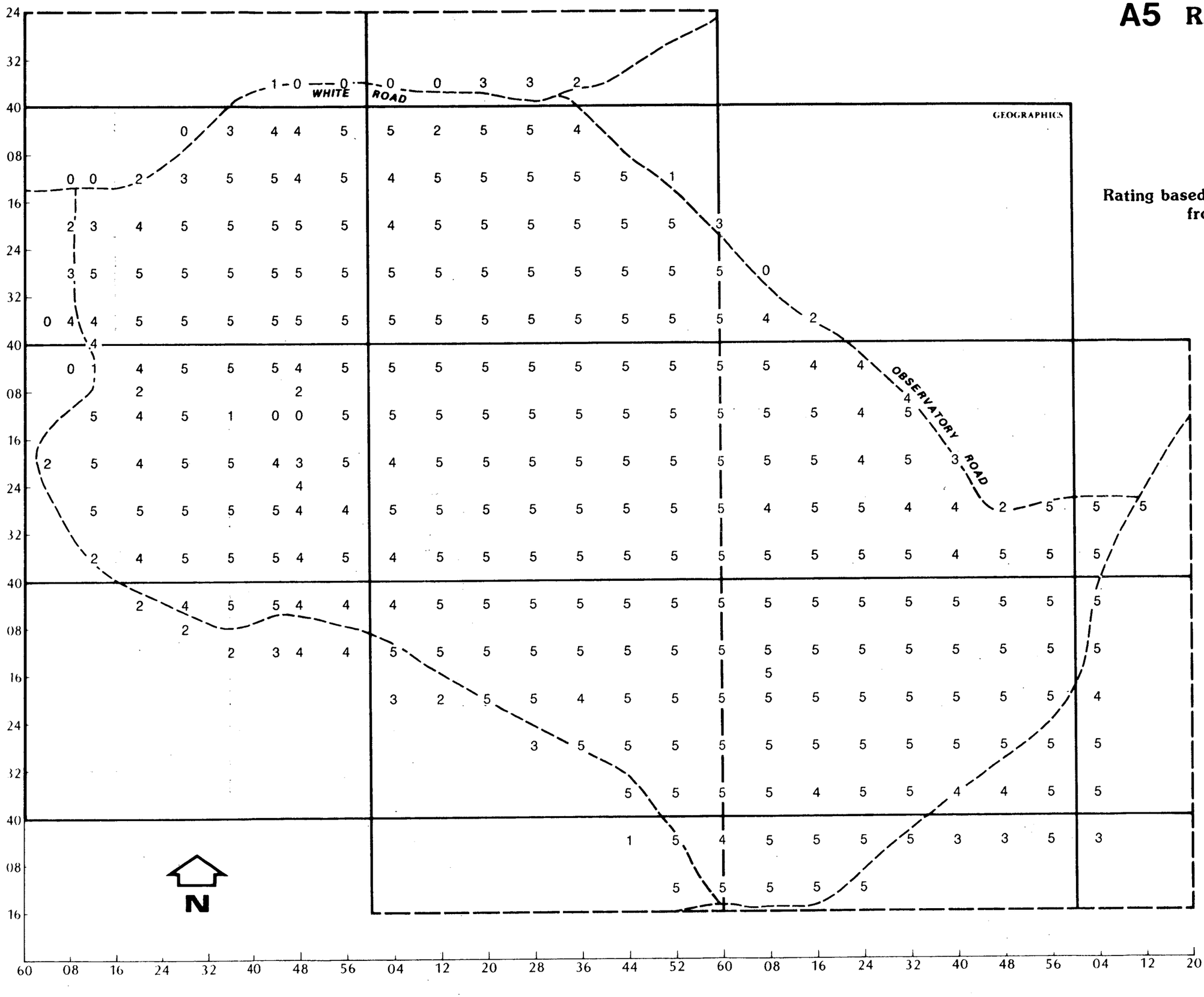
5 **More than one half of total stand**

SCALE 1:10 000

F4528	G4525		
F4604	G4601	G4602	
F4608	G4605	G4606	G4607
F4612	G4609	G4610	G4611
	G4613	G4614	G4615

A5 RATING OF TREES

Eucalyptus marginata



Rating based on an area of 20m radius from centre of recording site

0 **Absent**

1 **One or two trees**

2 **Three to five trees**

3 **More than five trees, but contributing less than one third of total stand**

4 **Between one third and one half of total stand**

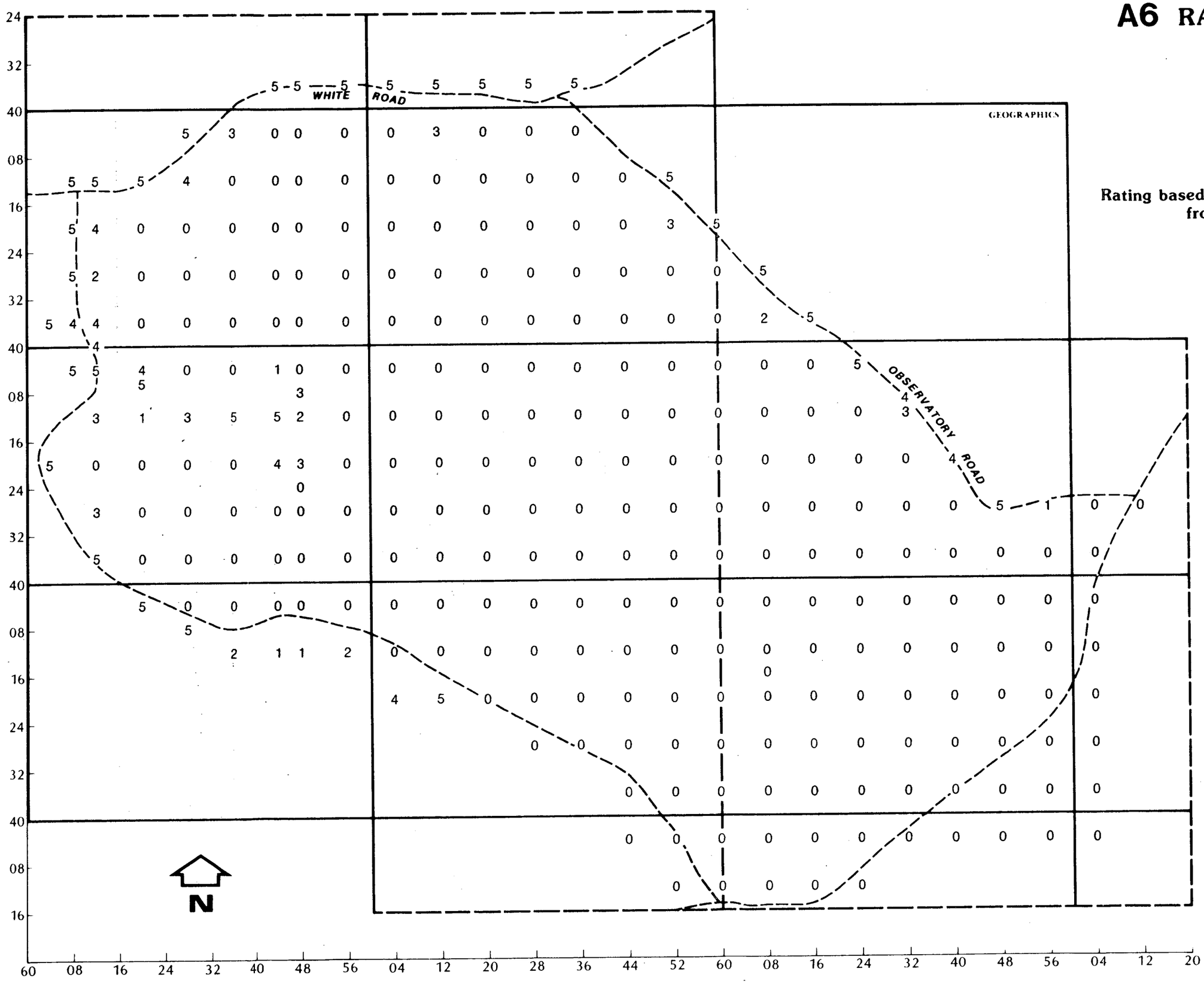
5 **More than one half of total stand**

SCALE 1:10 000

F4528	G4525		
F4604	G4601	G4602	
F4608	G4605	G4606	G4607
F4612	G4609	G4610	G4611
	G4613	G4614	G4615

A6 RATING OF TREES

Eucalyptus megacarpa



Rating based on an area of 20m radius from centre of recording site

0 Absent

1 One or two trees

2 Three to five trees

3 More than five trees, but contributing less than one third of total stand

4 Between one third and one half of total stand

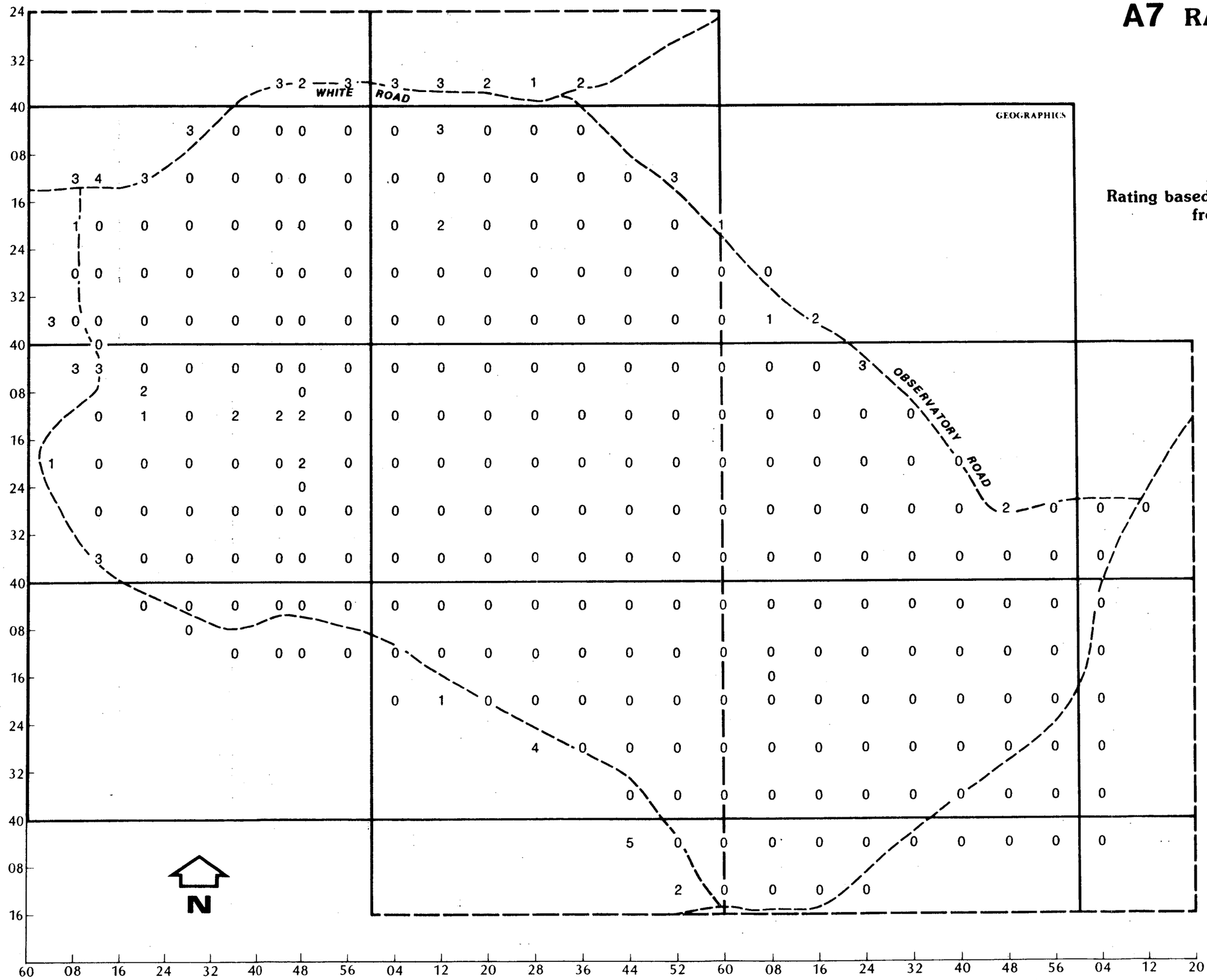
5 More than one half of total stand

SCALE 1:10 000

F4528	G4525		
F4604	G4601	G4602	
F4608	G4605	G4606	G4607
F4612	G4609	G4610	G4611
	G4613	G4614	G4615

A7 RATING OF TREES

Eucalyptus patens



Rating based on an area of 20m radius from centre of recording site

0 **Absent**

1 **One or two trees**

2 **Three to five trees**

3 **More than five trees, but contributing less than one third of total stand**

4 **Between one third and one half of total stand**

5 **More than one half of total stand**

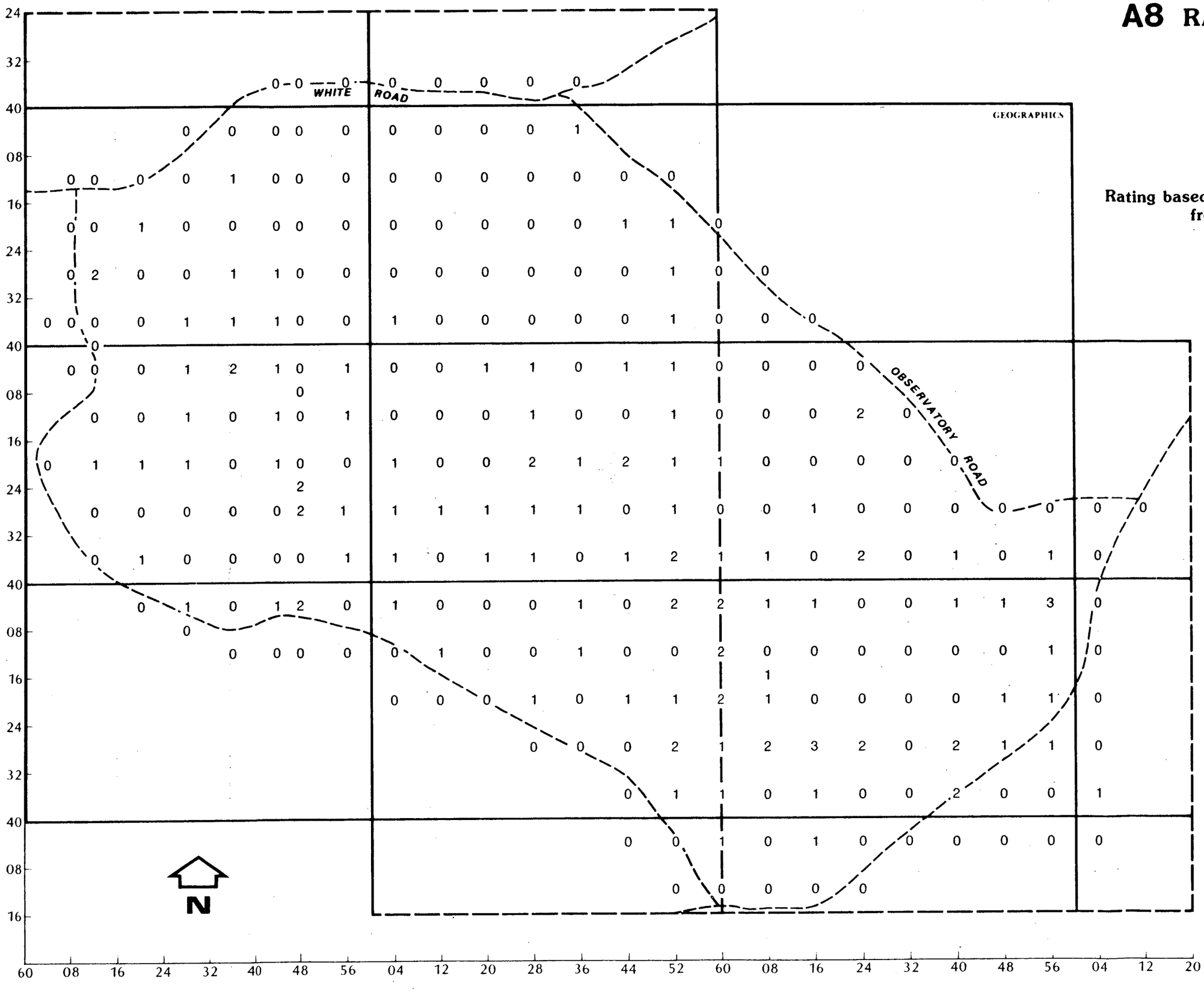
SCALE 1:10 000

F4528	G4525		
F4604	G4601	G4602	
F4608	G4605	G4606	G4607
F4612	G4609	G4610	G4611
	G4613	G4614	G4615

A8 RATING OF TREES

Persoonia elliptica

Rating based on an area of 20m radius from centre of recording site



0 Absent

1 One or two trees

2 Three to five trees

3 More than five trees, but contributing less than one third of total stand

4 Between one third and one half of total stand

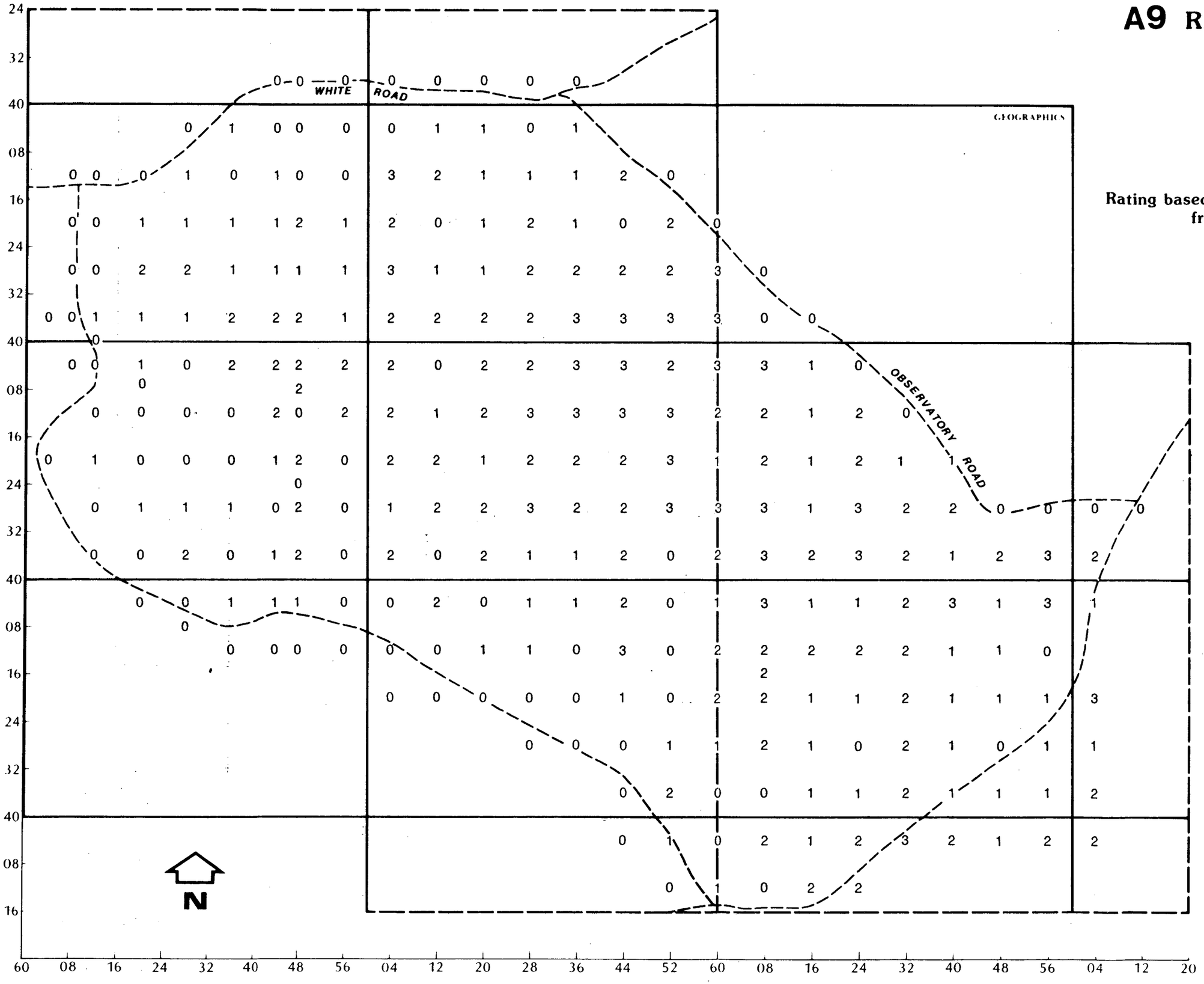
5 More than one half of total stand

SCALE 1:10 000

F4528	G4525		
F4604	G4601	G4602	
F4608	G4605	G4606	G4607
F4612	G4609	G4610	G4611
	G4613	G4614	G4615

A9 RATING OF TREES

Persoonia longifolia



Rating based on an area of 20m radius from centre of recording site

0 Absent

1 One or two trees

2 Three to five trees

3 More than five trees, but contributing less than one third of total stand

4 Between one third and one half of total stand

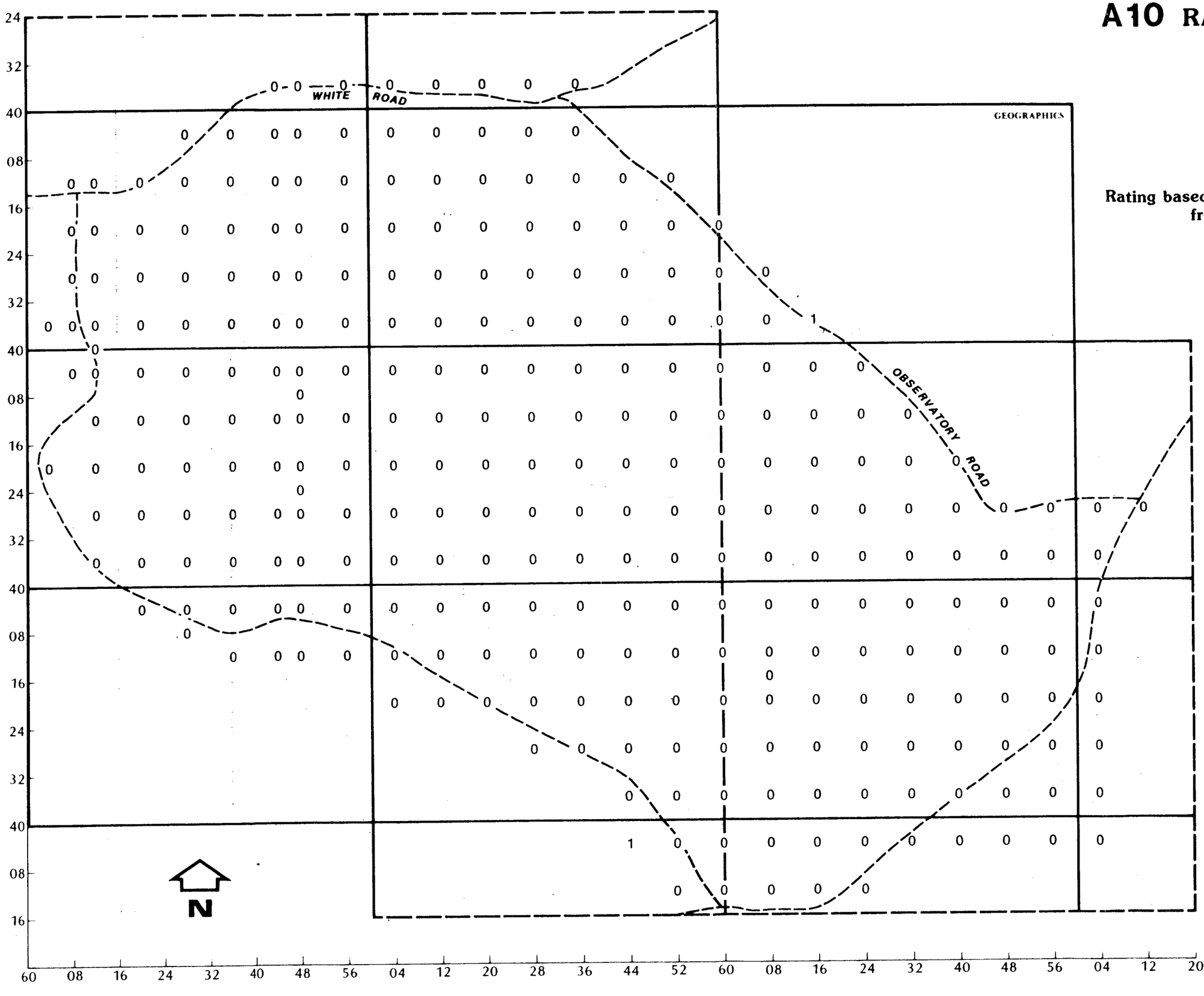
5 More than one half of total stand

SCALE 1:10 000

F4528	G4525		
F4604	G4601	G4602	
F4608	G4605	G4606	G4607
F4612	G4609	G4610	G4611
	G4613	G4614	G4615

A10 RATING OF TREES

Melaleuca preissiana



Rating based on an area of 20m radius from centre of recording site

0 Absent

1 One or two trees

2 Three to five trees

3 More than five trees, but contributing less than one third of total stand

4 Between one third and one half of total stand

5 More than one half of total stand

SCALE 1:10 000

F4528	G4525		
F4604	G4601	G4602	
F4608	G4605	G4606	G4607
F4612	G4609	G4610	G4611
	G4613	G4614	G4615

APPENDIX B

BOTANICAL STUDIES AT URBRAE HYGIENE MINING AREA

STRESS ASSESSMENT

B1 - Stress Assessment - Banksia grandis

B2 - Stress Assessment - Banksia littoralis

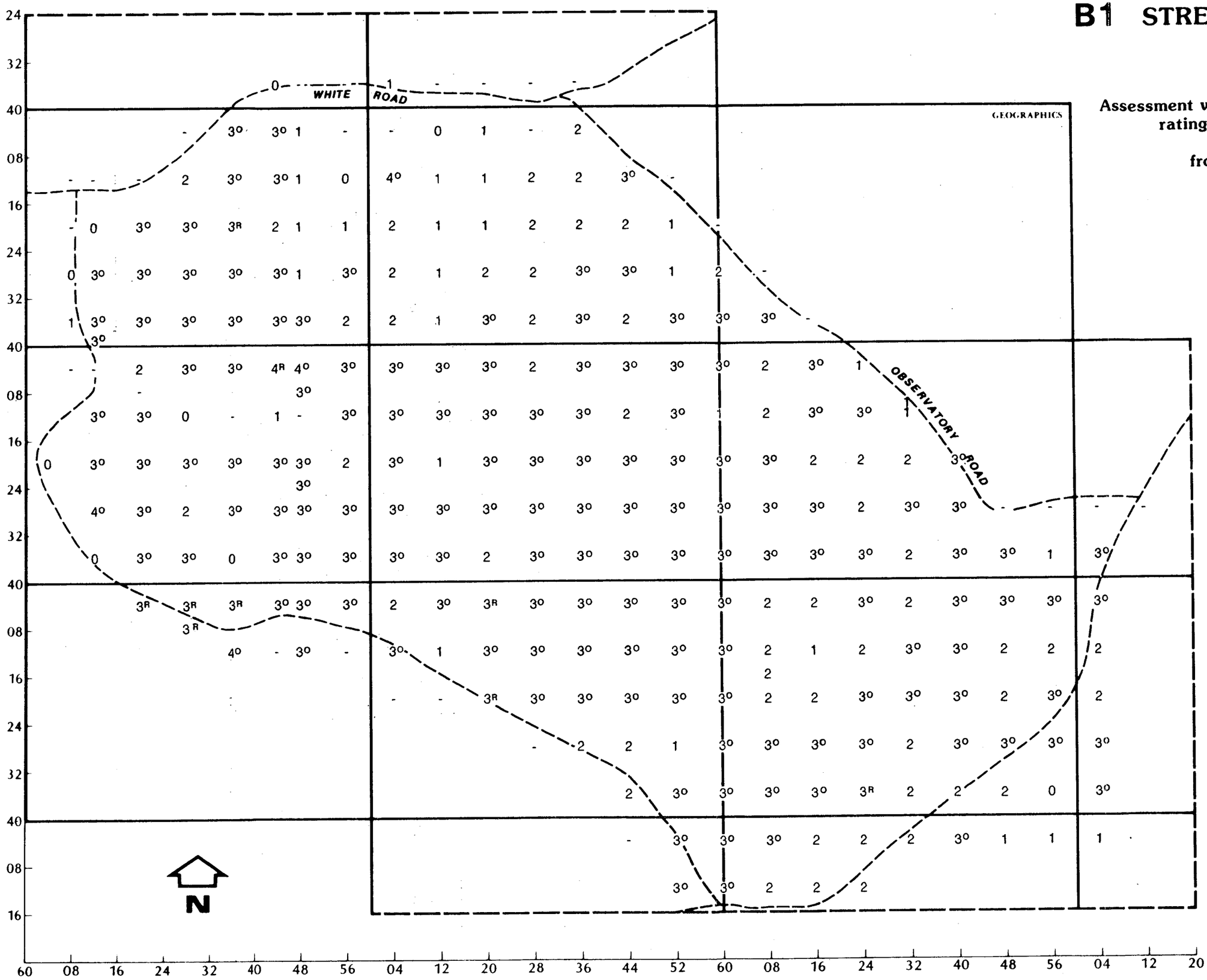
B3 - Stress Assessment - Eucalyptus marginata

B4 - Stress Assessment - Persoonia longifolia

B1 STRESS ASSESSMENT

Banksia grandis

Assessment was based on the following ratings in Banksia grandis trees in an area of 20m radius from centre of recording site



STRESS RATE

0 No evidence of stress in plants

1 Odd plant showing signs of stress, none dead

2 One or two stressed plants, usually under severe stress, near death (but not dead)

3 Scattered stressed and dead plants around plot

4 Susceptible plants dying or dead

5 "Graveyard" death - most trees logged or salvaged in many instances

INTERPRETATION CODE

o Old deaths

R Recent deaths

s Old stag trees

SCALE 1:10 000

F4528	G4525		
F4604	G4601	G4602	
F4608	G4605	G4606	G4607
F4612	G4609	G4610	G4611
	G4613	G4614	G4615

B2 STRESS ASSESSMENT

Banksia littoralis

Assessment was based on the following ratings in Banksia littoralis trees in an area of 20m radius from centre of recording site

STRESS RATE

0 No evidence of stress in plants

1 Odd plant showing signs of stress, none dead

2 One or two stressed plants, usually under severe stress, near death (but not dead)

3 Scattered stressed and dead plants around plot

4 Susceptible plants dying or dead

5 "Graveyard" death - most trees logged or salvaged in many instances

INTERPRETATION CODE

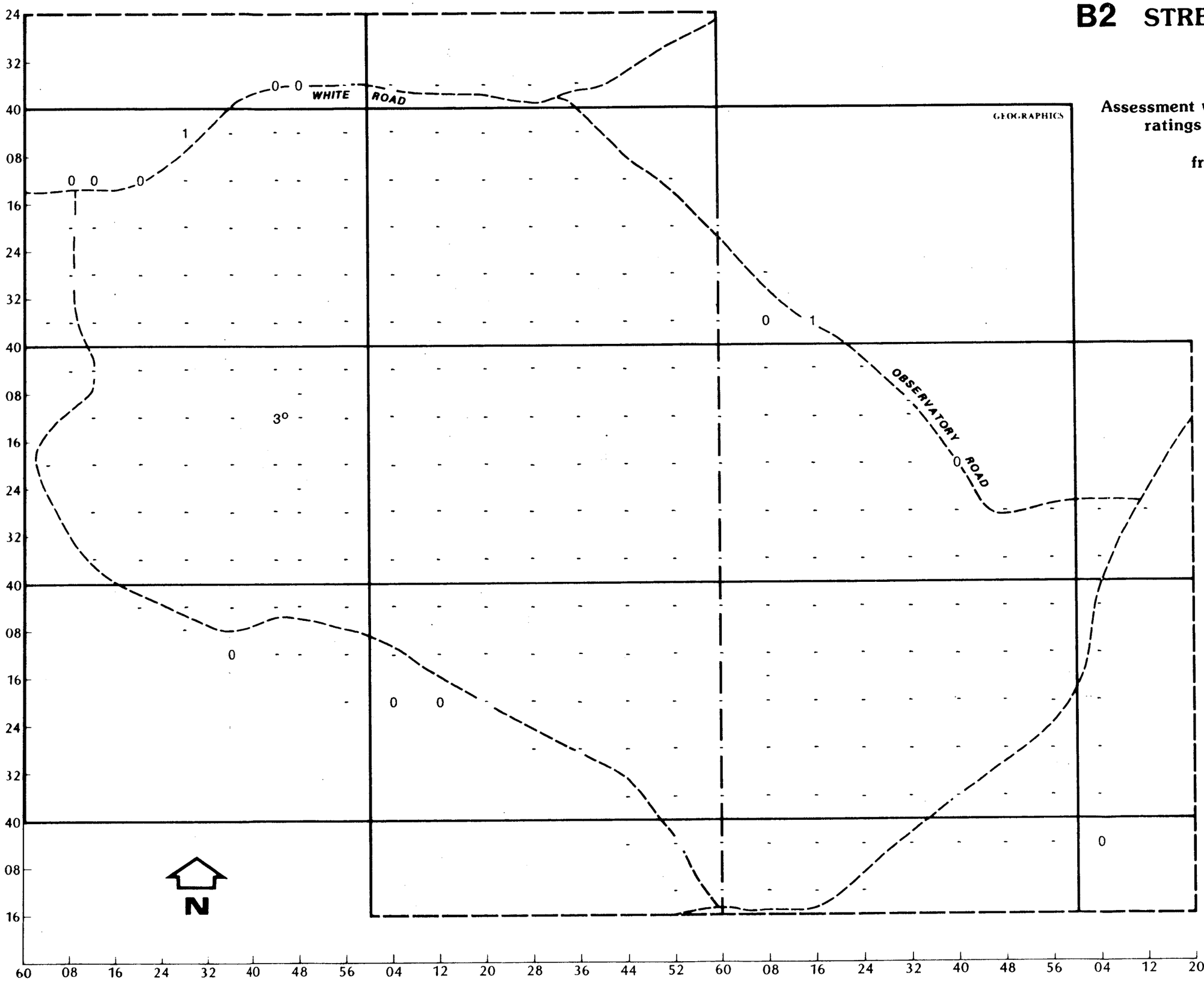
o Old deaths

R Recent deaths

s Old stag trees

SCALE 1:10 000

F4528	G4525		
F4604	G4601	G4602	
F4608	G4605	G4606	G4607
F4612	G4609	G4610	G4611
	G4613	G4614	G4615



B3 STRESS ASSESSMENT

Eucalyptus marginata

Assessment was based on the following ratings in Eucalyptus marginata trees in an area of 20m radius from centre of recording site

STRESS RATE

0 No evidence of stress in plants

1 Odd plant showing signs of stress, none dead

2 One or two stressed plants, usually under severe stress, near death (but not dead)

3 Scattered stressed and dead plants around plot

4 Susceptible plants dying or dead

5 "Graveyard" death - most trees logged or salvaged in many instances

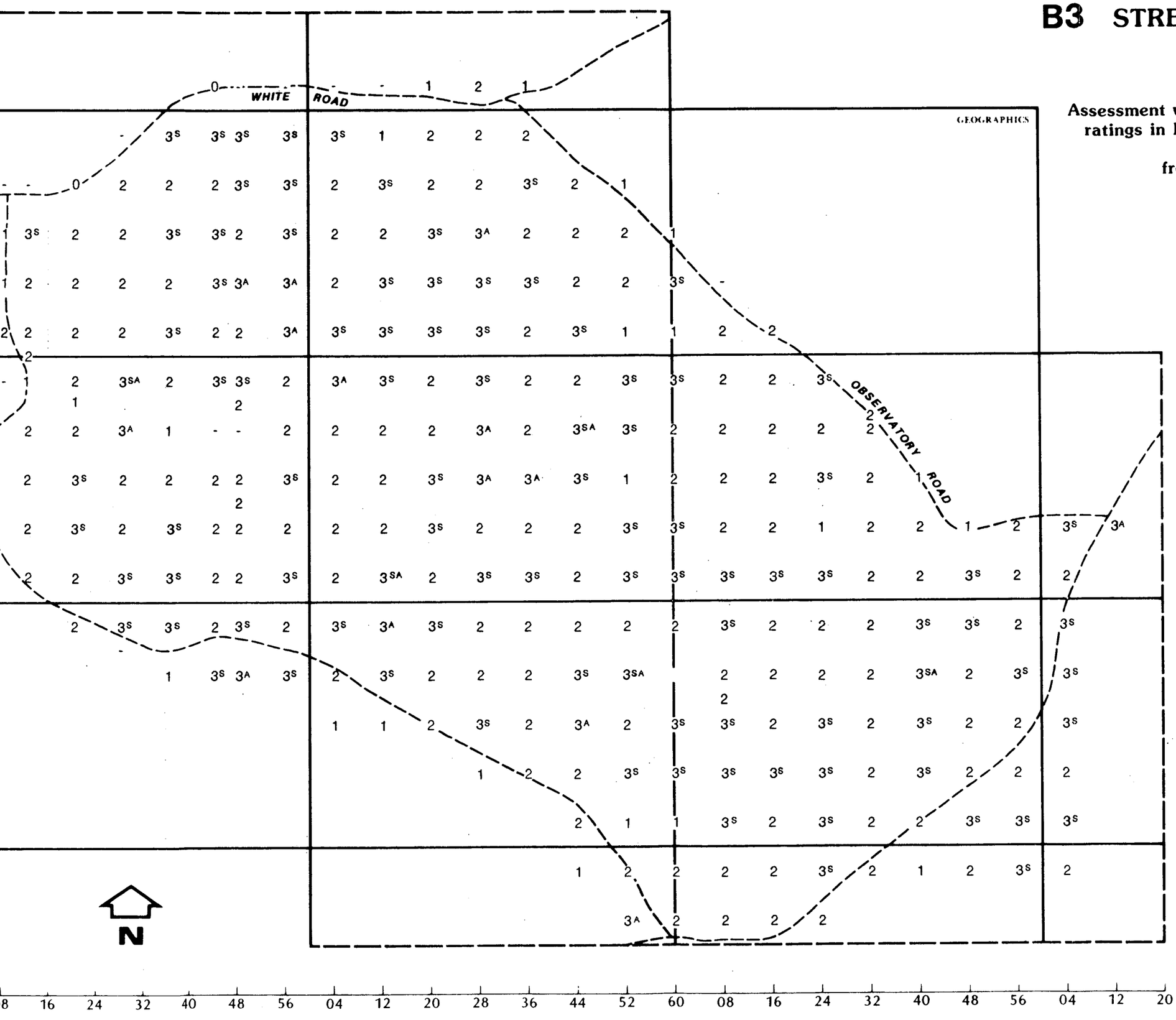
INTERPRETATION CODE

A Alternative causes of old deaths

B Recent deaths

S Old stag trees

SCALE 1:10 000



F4528	G4525		
F4604	G4601	G4602	
F4608	G4605	G4606	G4607
F4612	G4609	G4610	G4611
	G4613	G4614	G4615

B4 STRESS ASSESSMENT

Persoonia longifolia

Assessment was based on the following ratings in Persoonia longifolia trees in an area of 20m radius from centre of recording site

WHITE ROAD

GEOGRAPHICS

OBSERVATORY ROAD

N

STRESS RATE

0 No evidence of stress in plants

1 Odd plant showing signs of stress, none dead

2 One or two stressed plants, usually under severe stress, near death (but not dead)

3 Scattered stressed and dead plants around plot

4 Susceptible plants dying or dead

5 "Graveyard" death - most trees logged or salvaged in many instances

INTERPRETATION CODE

O Old deaths

R Recent deaths

S Old stag trees

SCALE 1:10 000

F4528	G4525		
F4604	G4601	G4602	
F4608	G4605	G4606	G4607
F4612	G4609	G4610	G4611
	G4613	G4614	G4615

APPENDIX C

BOTANICAL STUDIES AT URBRAE HYGIENE MINING AREA

SOILS

C1 - Soil Colour

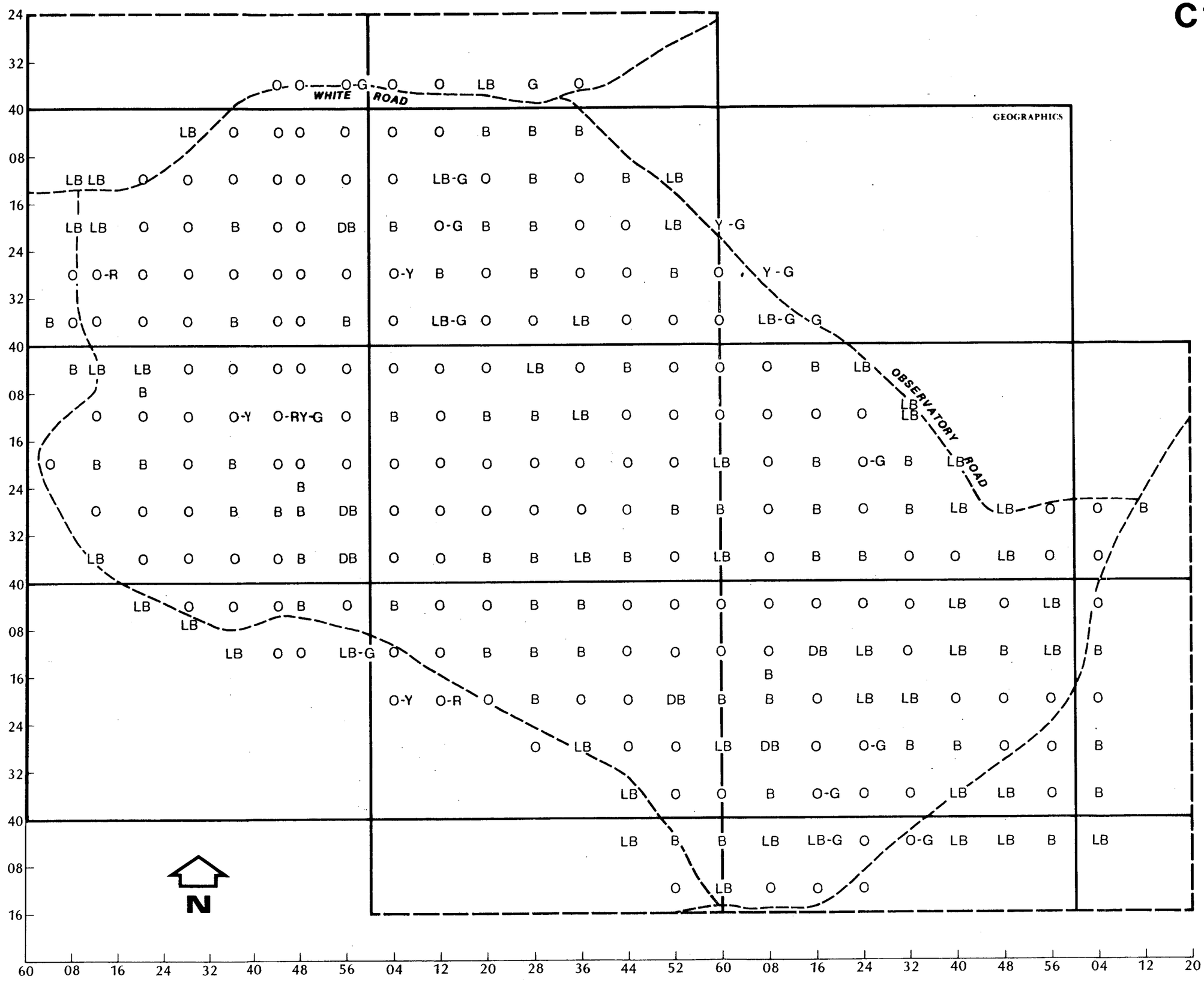
C2 - Soil Composition - Gravel Component

C3 - Soil Composition - Sand Component

C4 - Soil Composition - Silt Component

C5 - Boulders and Outcropping

C1 SOIL COLOUR



DB **Dark brown**

B **Brown**

LB **Light brown**

O **Orange**

R **Red**

Y **Yellow**

G **Grey**

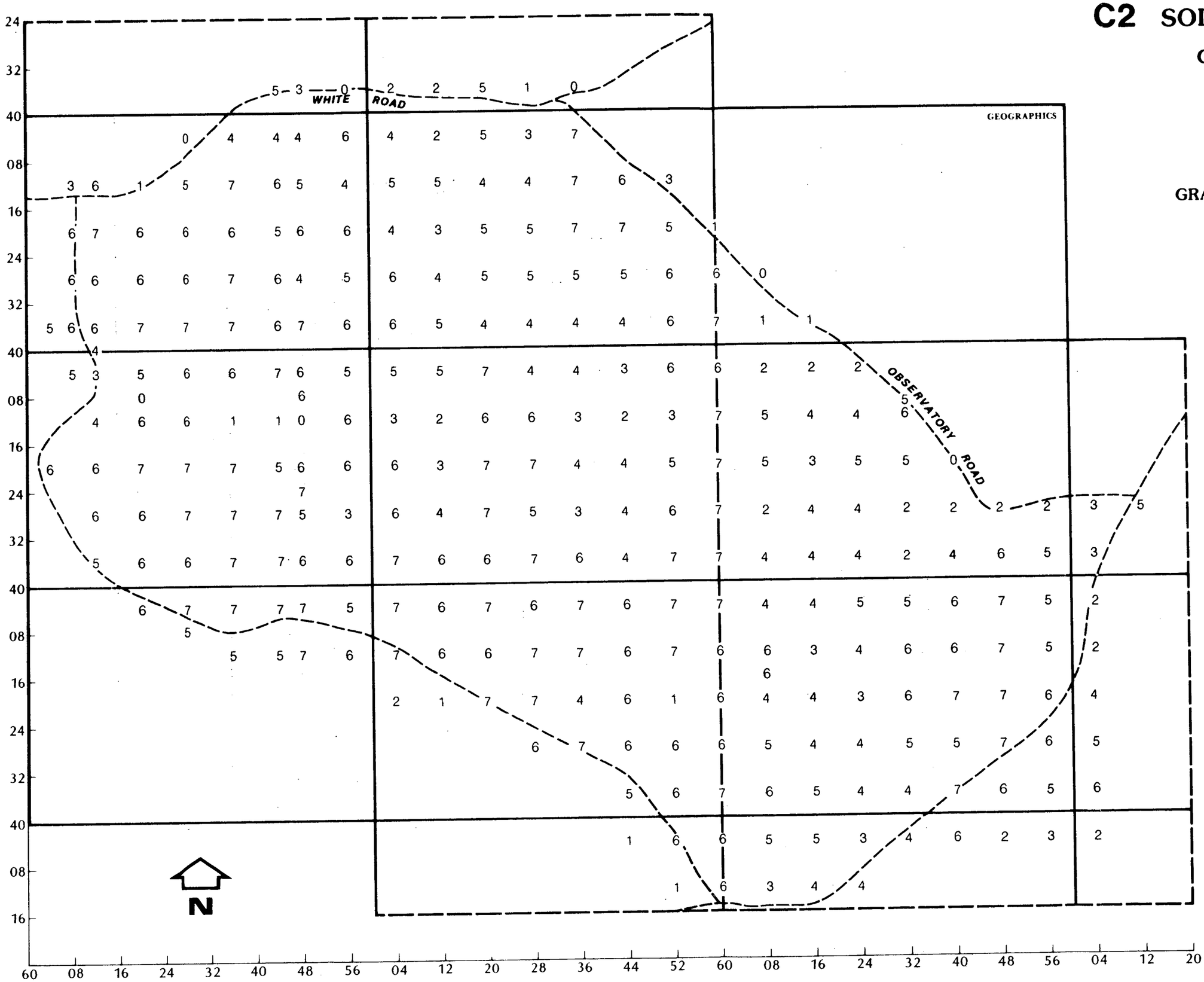
SCALE 1:10 000

F4528	G4525		
F4604	G4601	G4602	
F4608	G4605	G4606	G4607
F4612	G4609	G4610	G4611
	G4613	G4614	G4615

C2 SOIL COMPOSITION

GRAVEL COMPONENT

(Scale of 0-10, based on GRAVEL : SAND : SILT ratio at each recording site)



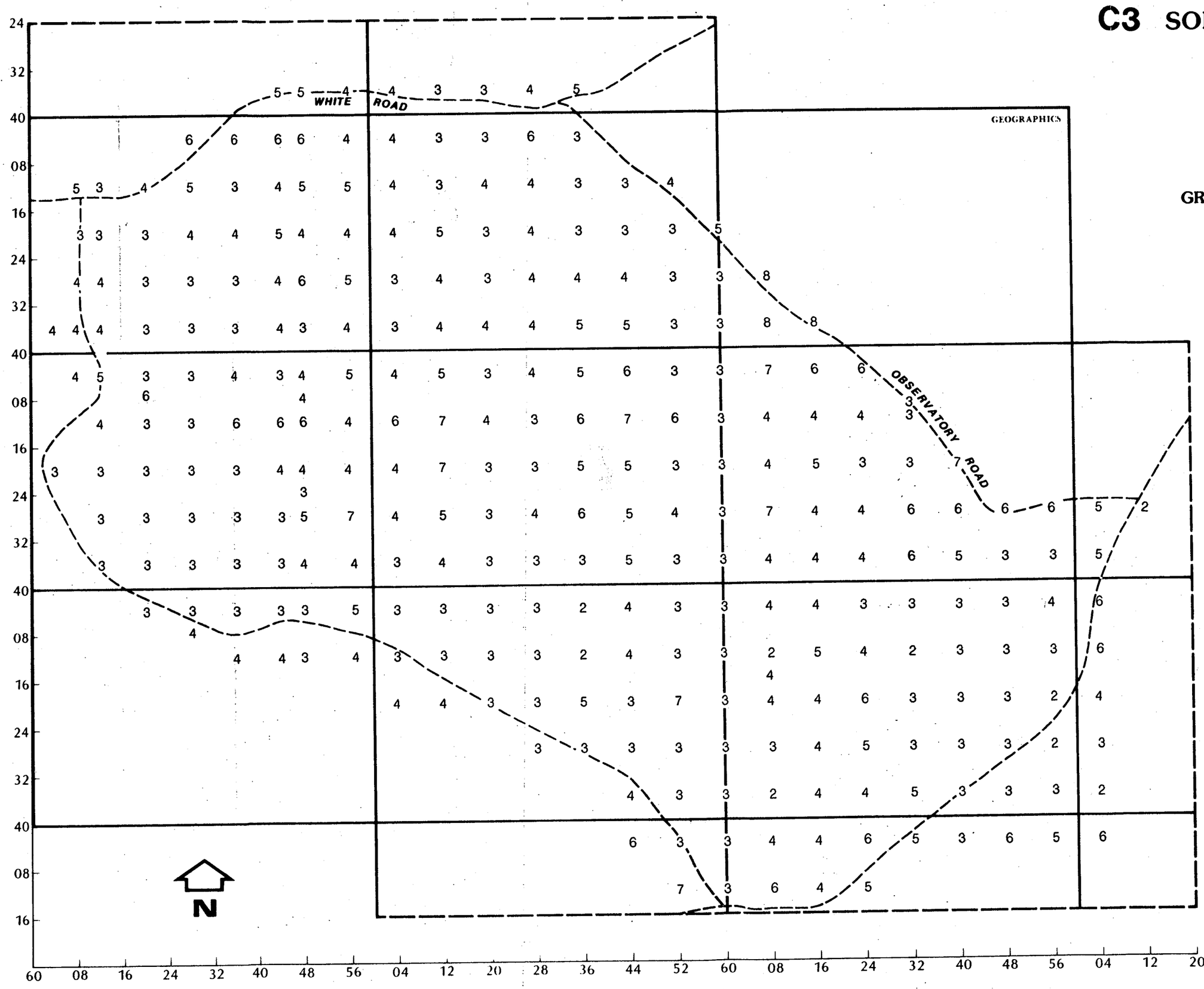
SCALE 1:10 000

F4528	G4525		
F4604	G4601	G4602	
F4608	G4605	G4606	G4607
F4612	G4609	G4610	G4611
	G4613	G4614	G4615

C3 SOIL COMPOSITION

SAND COMPONENT

(Scale of 0-10, based on GRAVEL : SAND : SILT ratio at each recording site)



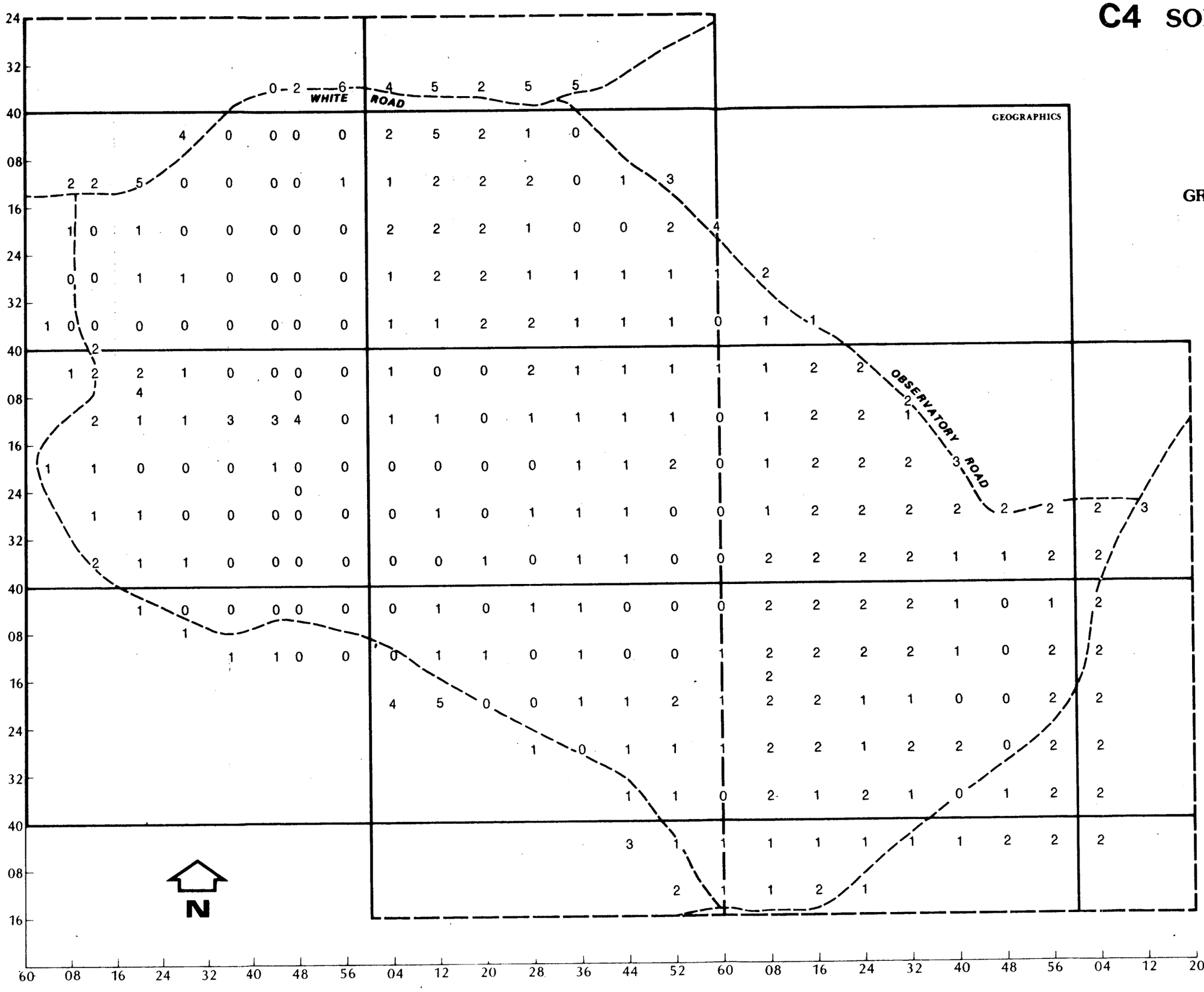
SCALE 1:10 000

F4528	G4525		
F4604	G4601	G4602	
F4608	G4605	G4606	G4607
F4612	G4609	G4610	G4611
	G4613	G4614	G4615

C4 SOIL COMPOSITION

SILT COMPONENT

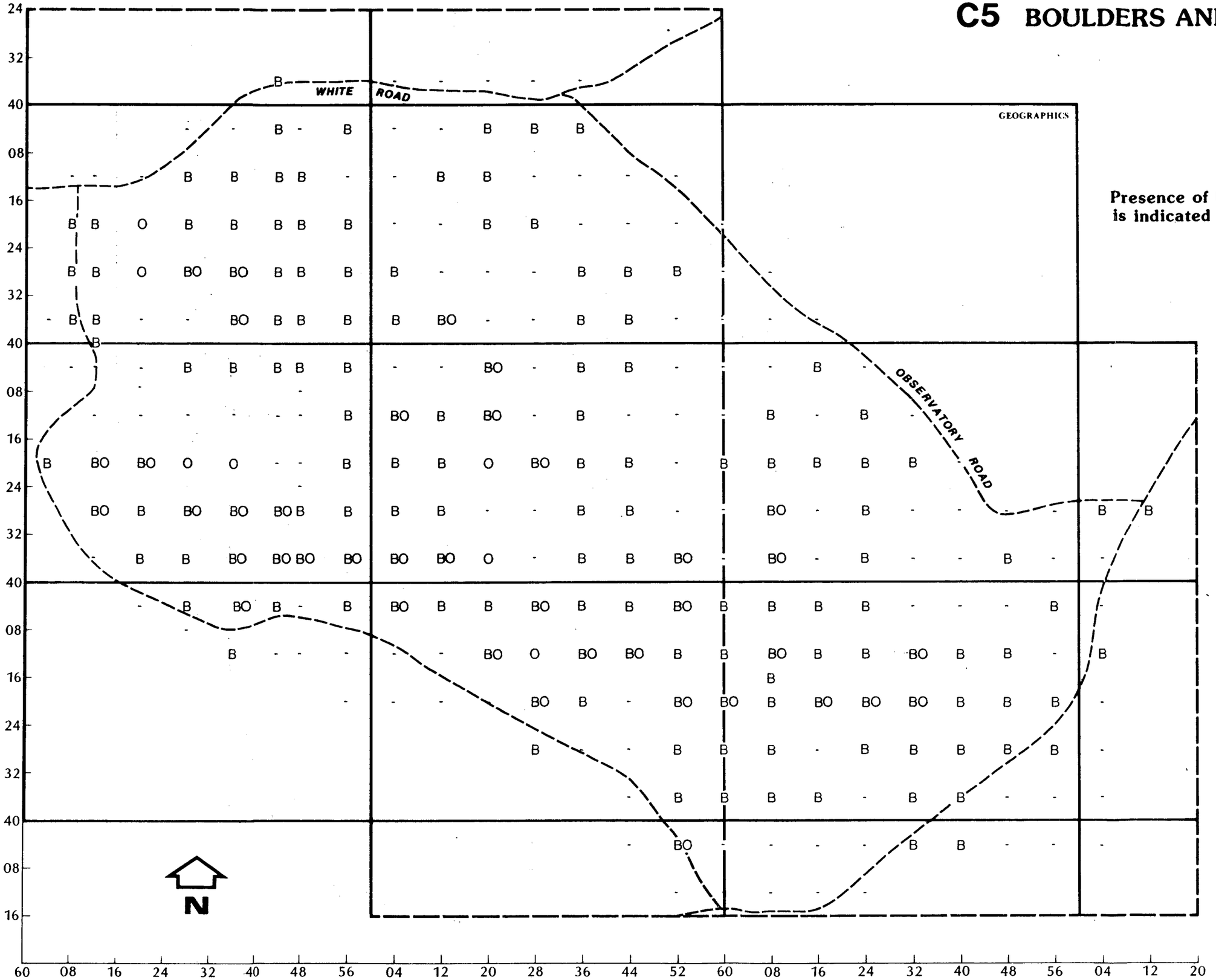
(Scale of 0-10, based on GRAVEL : SAND : SILT ratio at each recording site)



SCALE 1:10 000

F4528	G4525		
F4604	G4601	G4602	
F4608	G4605	G4606	G4607
F4612	G4609	G4610	G4611
	G4613	G4614	G4615

C5 BOULDERS AND OUTCROPPING



Presence of boulders and outcropping is indicated at each recording site by

B **Boulders**

O **Outcropping**

\- **Nil**

SCALE 1:10 000

F4528	G4525		
F4604	G4601	G4602	
F4608	G4605	G4606	G4607
F4612	G4609	G4610	G4611
	G4613	G4614	G4615

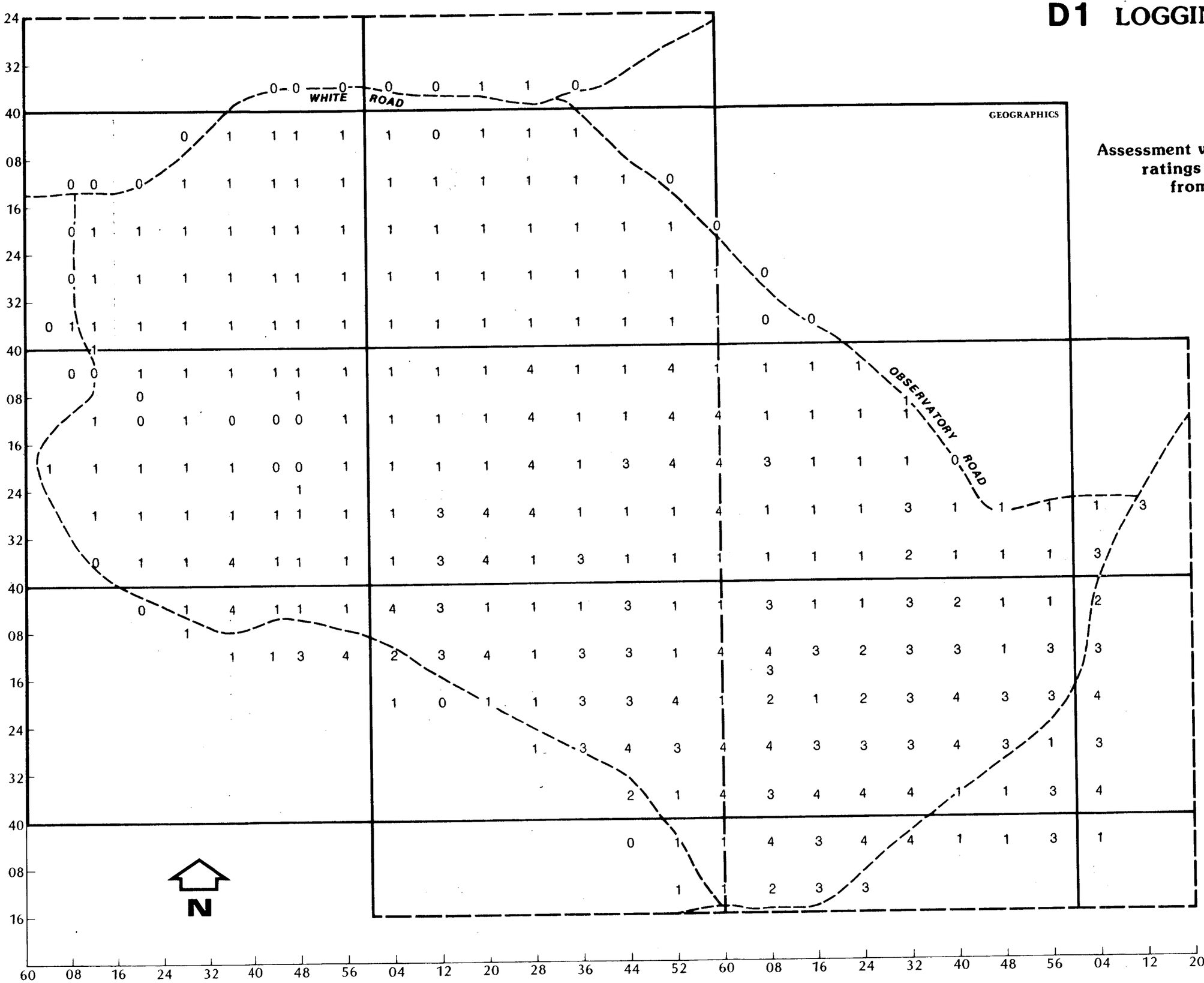
APPENDIX D

BOTANICAL STUDIES AT URBRAE HYGIENE MINING AREA

LOGGING ASSESSMENT

D1 - Logging Assessment

D1 LOGGING ASSESSMENT



Assessment was based on the following ratings in an area of 20m radius from centre of recording site

LOGGING RATE

0 No evidence of logging (absence of stumps)

1 Very old logging - one cut only (age of stumps all old)

2 Recent logging only - light logging rate (less than three stumps)

3 Old and recent logging - area cut over twice, light rate (less than three stumps)

4 Logging intensively - heavy logging rate (more than three stumps for each age)

5 "Graveyard" - salvage logging

SCALE 1:10 000

F4528	G4525		
F4604	G4601	G4602	
F4608	G4605	G4606	G4607
F4612	G4609	G4610	G4611
	G4613	G4614	G4615

APPENDIX E

BOTANICAL STUDIES AT URBRAE HYGIENE MINING AREA

VASCULAR PLANT LIST

URBRAE HYGIENE MINING AREA
VASCULAR PLANT LIST

FAMILY	GENERA	SPECIES
DENNSTAEDTIACEAE		
	Pteridium	aquilinim
ZAMIACEAE		
	Macrozamia	riedlei
CYPERACEAE		
	Cyathochaeta	avenacea
	Gahnia	decomposita
	Lepidosperma	angustatum
	Lepidosperma	tenue
	Lepidosperma	tetraquetrum
	Lepidosperma	sp.
RESTIONACEAE		
	Leptocarpus	scariosus
LILIACEAE		
	Xanthorrhoea	gracilis
	Xanthorrhoea	preissii
CASUARINACEAE		
	Allocasuarina	fraseriana
PROTEACEAE		
	Adenanthos	barbigerus
	Banksia	grandis
	Banksia	littoralis
	Hakea	amplexicaulis
	Hakea	lissocarpha
	Hakea	ruscifolia
	Hakea	undulata
	Persoonia	elliptica
	Persoonia	longifolia
	Xylomelum	occidentale

URBRAE HYGIENE MINING AREA
VASCULAR PLANT LIST (continued)

FAMILY	GENERA	SPECIES
SANTALACEAE		
	Leptomeria	cunninghamii
RANUNCULACEAE		
	Clematis	pubescens
PITTOSPORACEAE		
	Sollya	heterophylla
LEGUMINOSAE		
SUBFAM. MIMOSACEAE		
	Acacia	divergens
	Acacia	drummondii
	Acacia	extensa
	Acacia	lateriticola
	Acacia	preissiana
	Acacia	pulchella
	Acacia	semitrullata
	Acacia	urophylla
LEGUMINOSAE		
SUBFAM. PAPILIONOIDEAE		
	Bossiaea	aquifolium
	Bossiaea	ornata
	Daviesia	cordata
	Daviesia	decurrens
	Daviesia	incrassata
	Daviesia	preissii
	Daviesia	rhombifolia
	Hovea	chorizemifolia
	Kennedia	coccinea
	Kennedia	prostrata
	Mirbelia	dilatata
	Sphaerolobium	medium

VASCULAR PLANT LIST (continued)

FAMILY	GENERA	SPECIES
RUTACEAE		
	Boronia	crenulata var. gracilis
	Boronia	fastigiata
	Boronia	molloyae
EUPHORBIACEAE		
	Phyllanthus	calycinus
	Stachystemon	vermicularis
RHAMNACEAE		
	Trymalium	ledifolium
STERCULIACEAE		
	Lasiopetalum	floribundum
	Thomasia	paniculata
DILLENIACEAE		
	Hibbertia	amplexicaulis
	Hibbertia	aff. gracilipes
	Hibbertia	perfoliata
	Hibbertia	sp.
MYRTACEAE		
	Agonis	linearifolia
	Astartea	fascicularis
	Callistemon	speciosus
	Eucalyptus	calophylla
	Eucalyptus	marginata
	Eucalyptus	megacarpa
	Eucalyptus	patens
	Hypocalymma	cordifolium

VASCULAR PLANT LIST (continued)

FAMILY	GENERA	SPECIES
EPACRIDACEAE		
	Astroloma	ciliatum
	Astroloma	pallidum
	Leucopogon	capitellatus
	Leucopogon	oxycedrus
	Leucopogon	propinquus
	Leucopogon	verticillatus
	Styphelia	tenuiflora
LAMIACEAE		
	Hemigenia	pritzelii
GOODENIACEAE		
	Lechenaultia	biloba