Natural revegetation of an abandoned quarry, Sydney

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Morrison, David A.; Butt, Lorne; Holland, David; Westbury, Anne-Maree (Department of Environmental Sciences, University of Technology Sydney, Westbourne Street Gore Hill, NSW 2065, Australia) 2001. Natural revegation of an abandoned quarry, Sydney. Cunninghamia *7(2): 157–171*.

A 0.6 ha area in North Wahroonga, Sydney NSW, where the plant and soil cover had been completely removed to expose the underlying sandstone rock surface, was examined in 1997, c. 70 years after the disturbance ceased. The area has remained relatively undisturbed since the 1920s, and the revegetation has been allowed to proceed unhindered. In total, 146 species were encountered in and around the area, 126 of them occurring in the quarried area. Twenty-six of these species are not native to the area, but they occurred almost exclusively in the south-east quarry working, which is adjacent to the closest residential area. The three quarry workings were clearly floristically distinct from each other, with the south-east quarry working differing from the other two in having many unique species (mainly the introduced species) and the east working being floristically de-pauperate. None of the measured soil physical or chemical variables was particularly correlated with the variation in floristic composition. There was a partial distinction between the plant species composition of the quarried area and the adjacent undisturbed area, with 17% of the native species encountered not occurring in the quarried area and a further 10% showing a significantly lower abundance in this area. However, the distinctive south-east quarry working was floristically no more different from the rest of the quarry than was the native area last burnt in 1990 from the native area last burnt in 1968, and the quadrats in the long-unburnt native area were rather similar in species composition to those of the north and east quarry workings. However, many of the species in long-unburnt vegetation will be represented in the community solely by a soil seedbank, and so this comparison of above-ground vegetation may be artificial. The soil structure and fertility both showed no consistent differences between the native area and the quarried area.

Introduction

The temporal trends in floristic composition observed during primary successions (the replacement through time of one group of species by another on substrates with no previous history of biota) are usually thought of as being quite different from the temporal trends in plant dynamics of vegetated areas (secondary successions and fluctuations), and they are likely to be a response to quite different environmental factors. The factors that are generally considered to be important in primary successional dynamics include nutrient deficiency, substrate instability, and lack of an indigenous seed source (Miles & Walton 1993).

The best-known examples of primary succession include newly exposed debris around active volcanoes and retreating glaciers, although examples from rock faces, fellfield, sand-dunes and saltmarsh are also known (Miles & Walton 1993). Australia is almost completely unglaciated and is tectonically relatively stable, and so the opportunities for studying primary succession are relatively limited. However, human activities often result in a pulse disturbance that exposes virgin surfaces, which can act as substrates for colonization (e.g. Morrison et al. 1995b). Extraction industries, for example, tend to have localized effects that involve the total loss of vegetation, being responsible for a decline or change to 3.5% of the plant associations in NSW (Benson 1991). Quarrying is a surface-mining technique that results in all of the soil and strata overlying the deposit being removed, thus being one potential source of primary successions. Note that the concept of primary succession specifically excludes situations where revegetation is artificially fostered (such as sand mining, e.g. Bradshaw 1997), or where a continuing press disturbance occurs.

This paper reports the results of a study of a 0.6 ha area in North Wahroonga, Sydney NSW, which had its plant and soil cover completely removed in order to form a quarry of the underlying rock during the early 1900s. The quarry was abandoned in the 1920s, and the area has remained relatively undisturbed since that time, so that the revegetation has been allowed to proceed unhindered and unassisted. Our study was conducted in 1997, some 70 years after the cessation of the disturbance.

Our study seeks to answer four basic questions: (1) What is the pattern of plant species composition on the quarried area? (2) Does this pattern relate to any environmental factors? (3) What is the pattern of plant species composition between the quarried area and the adjacent native area? and (4) Does this pattern relate to any environmental factors?

Geographic setting

The study area (Fig. 1) is adjacent to the Cook Trigonometric Station (33°42'S, 151°07'E), North Wahroonga, in the northern suburbs of Sydney. The study area is immediately to the north and east of the Trig. station, overlooking the headwaters of Fraser Brook. This is on the dissected sandstone Hornsby Plateau, although the site itself lies near the geological interface of the Wianamatta Shale on the Wahroonga Plateau and the exposed Hawkesbury Sandstone of the Cowan Creek Escarpment. The surrounding vegetation reflects this interface, although in the broader sense it is typical dry sclerophyll forest of the local area (Thomas & Benson 1985, Benson & Howell 1994).

Jones' Quarry was a dimension stone quarry for sandstone blocks, established in the early 1900s by John Jones, who set up a depot and sand yard at the Wahroonga railway siding (Ford 1996). The sandstone was used for the construction of houses and roads in the vicinity. After the widespread introduction of concrete for building, the quarry was no longer profitable, and operations ceased sometime during the 1920s. Most disused quarries have been used for fill or rubbish dumping as urbanization has proceeded, and Jones' Quarry remains as the last example of an undisturbed dimension stone quarry in the region (Ford 1996).

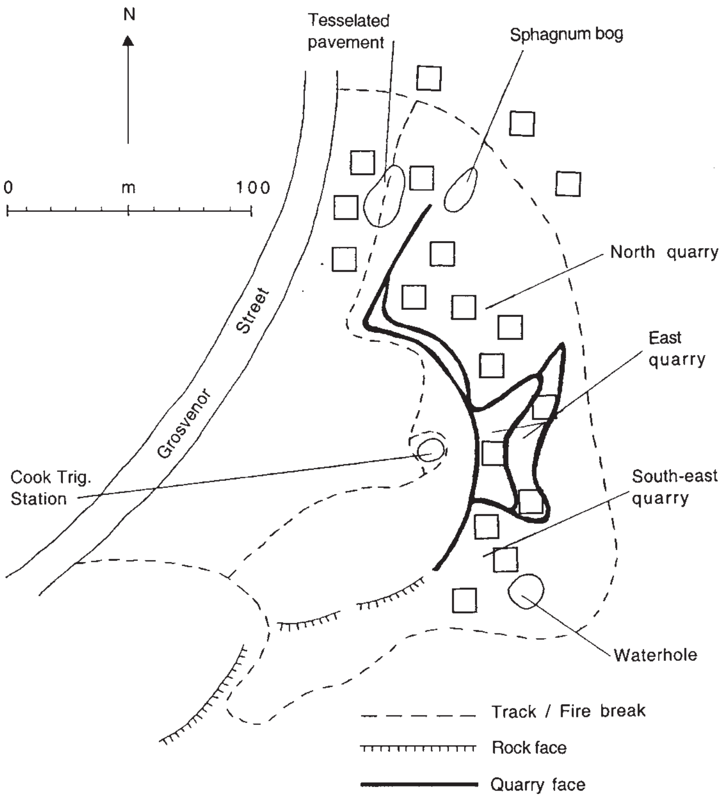

Fig. 1. Map of the study area at North Wahroonga, in the northern suburbs of Sydney, showing the features of the Jones Quarry and surrounds as referred to in the text. The squares indicate the location of the 18 quadrats used for the determination of floristic composition and the collection of soil samples.

The quarry had three identifiable working areas (Fig. 1): the main working quarry facing approximately north, another to the east, and a third to the south-east. Broken steps remain where the quarriers worked the horizontal fault lines, and the eastern working remains at two distinct levels where the cutting was left unfinished prior to being abandoned.

The area immediately to the north and east of the quarry is relatively undisturbed bushland managed by the local council, which then abuts Ku-ring-gai Chase National Park. Immediately to the west of the vertical quarry wall is the Cook Trig. Heritage Area, and relatively undisturbed bushland subject to a development proposal for housing, which abuts Grosvenor Road. Immediately to the south of the quarry is the current northern edge of the North Wahroonga residential area. A vehicular track leaves Grosvenor Road to the north, and passes around the northern and eastern side of the quarry, acting as a fire break. The land to the north and east of this trail has been subject to regular bushfires, but the bushland to the south and west of this trail has not been burnt since a wildfire in 1968, apart from a very small arson fire near the houses.

Most of the quarried area has remained relatively undisturbed since excavation ceased, allowing unimpeded but unaided revegetation. The habitat varies from bare rock through skeletal soils to small wetlands. At the northern extremity of the north working is a sphagnum bog with an overflow pool. The face of the south-east working is the tallest, and enough groundwater seeps out of the faultlines to create a moss habitat immediately below the face. Groundwater in this working flows continuously into a natural rock waterhole from a level below the quarry face, although the hole has been partially filled in. Parts of the quarry are used regularly as a thoroughfare by local residents taking a stroll or walking their dogs.

Materials and methods

Plant data

The floristic composition was determined from eleven 10 m x 10 m quadrats in the quarried area and seven similar quadrats in the adjacent vegetation (Fig. 1). In the quarried area, five of the quadrats were placed in the north working, three quadrats in the south-east working, one quadrat on the top shelf of the east working and two quadrats on the lower shelf. Within the native vegetation, four of the quadrats were placed in the area that had not been burnt since the 1968 wildfire, while the remaining three quadrats were in an area that had been last burnt by a low-intensity fire in 1990.

The abundance of each vascular plant species was estimated for each sample using the nested-quadrat technique of Outhred (1984), with importance scores assigned to each species in each quadrat using seven square sub-quadrats varying from 1 to 100 m^2. This technique produces abundance scores (on a scale of 1–7) that are functionally equivalent to frequencies (Morrison et al. 1995a), which are directly related to plant density (Bonham 1989). All species nomenclature follows Harden (1990–1993).

Environmental data

A 1000 cm^3 soil sample was taken from near the centre of each of the 18 quadrats, and removed to the laboratory for physical and chemical analysis. The soil depth throughout the quarried area was recorded by hammering a marked pole into the ground every 5 m along 28 transects running parallel to each of the three vertical quarry faces and 4 m apart (a total of 170 measurements).

In the laboratory, the oven-dried soil samples were analysed for ppm available soil phosphorus by the orthophosphate method of Bray & Kurtz, as described by Page et al. (1984); % soil organic matter by loss on ignition at 550˚C, using the method of Grimshaw (1989); and % gravel (particles >2 mm diam.), % fine sand (0.1–2 mm diam.) and % silt and clay (<0.1 mm diam.) by the dry sieving method, as outlined by Grimshaw (1989).

Data analysis

Species-centred principal components analysis (PCA) of the floristic data (ter Braak 1988) was used to analyse the pattern of variation in plant species composition among the quadrat samples. Two separate analyses were run, one using only the data for the 11 quadrats from the quarried area, and one using all 18 quadrats.

The effects of the soil characteristics on the plant species composition were analysed by redundancy analysis (RDA) (ter Braak 1988). This is a constrained ordination technique based on principal components analysis that, in a joint analysis of the two data sets (i.e. floristic and environmental), assesses the degree to which they show co-variation (ter Braak & Prentice 1989). That is, it seeks patterns among the quadrats that occur in both data sets, while ignoring patterns that are unique to either one of the data sets alone; this is thus a direct gradient-analysis technique. Once again, two separate analyses were run, one using only the data for the 11 quadrats from the quarried area with all 6 environmental variables, and one using all 18 quadrats but excluding soil depth as an environmental variable (because depth could not be measured in the native area).

The pattern of abundance of each species between the quarried area and the adjacent native area was investigated using non-parametric Mann-Whitney U-tests of the quadrat data (Wilkinson 1987). This analysis was only performed for species that were recorded in more than one quadrat, and significance was assessed at the p=0.05 level. It should, however, be remembered that about 4 out of these 82 results could have a probability value of 0.05 or less by chance alone.

Results

In total, 146 species were encountered in this study (Appendix 1), 126 of them occurring in the quarried area and 20 found only in the adjacent native area. Twenty-six of these species are not native to the area, but only one of them (*Andropogon virginicus*) occurs outside of the south-east quarry working. Only 12 species were common to all of the study areas.

The ordination of the quadrats from the quarried workings shows a consistent spatial pattern of floristic composition within this area (Fig. 2a), the first two axes accounting for 42% of the total variation in floristic composition. The first axis (the primary pattern) separates the quadrats in the south-east quarry working from those in the other two areas, and the second axis (the secondary pattern) separates the quadrats in the east quarry working from those in the north working.

The south-east quarry working differs from the other two areas in having many unique species (Table 1). Indeed, 83 (57%) of the species encountered were found in the three quadrats of this area (Appendix 1), and 35 of these species were found solely within this area. Of these species, 26 are not native to the study site. The east quarry working differs from the north working in having fewer species (Table 1). If the introduced species are excluded from the calculations, then the south-east and north quarry workings have 47% and 48%, respectively, of the total number of species found in the quarry, while the east working has only 35% of them.

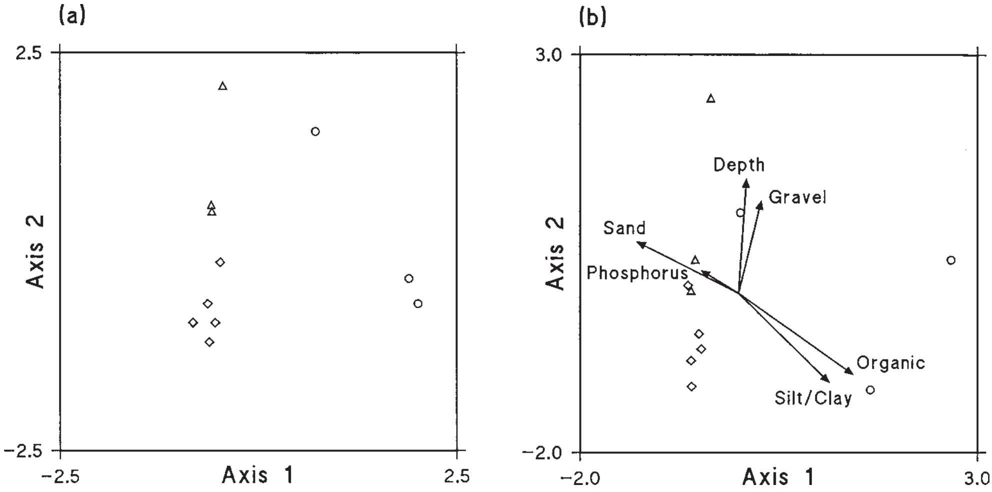

Fig. 2. Projection of the quadrats in the quarried area onto axes representing the first two components of **a,** the principal components analysis of the floristic data and **b,** the redundancy analysis of the floristic and soil variables data. (o) south-east, (Δ) east and (◊) north quarry-area quadrats; (Gravel) % gravel, (Sand) % sand, (Silt/Clay) % silt and clay, (Organic) % soil organic matter, (Phosphorus) ppm available soil phosphorus, (Depth) cm soil depth.

Table 1. Number of species in common between the different study areas. The diagonal shows the number of species unique to that area.

Area	Quarried area			Native area	
	North	East	South-east	Recently burnt	Long unburnt
North quarry working	7	—	—	—	—
East quarry working	24	13	—	—	—
South-east quarry working	*34	26	†35	—	—
Recently burnt adjacent native area	37	28	32	8	—
Long unburnt adjacent native area	40	29	36	44	8

* Includes 1 species not native to the study area
† Includes 25 species not native to the study area

The redundancy analysis of the quadrats from the quarried area shows a fairly strong relationship between the pattern of floristic composition and the measured soil variables (Fig. 2b), with the two axes shown accounting for 58% of the total sum of squares of the first two axes of the equivalent unconstrained ordination. In particular, two of the quadrats from the south-east quarry working had more silty/clayey soil with more organic matter, while the other south-east quarry quadrat and the quadrat from the upper shelf of the east quarry had deeper and more gravelly soil.

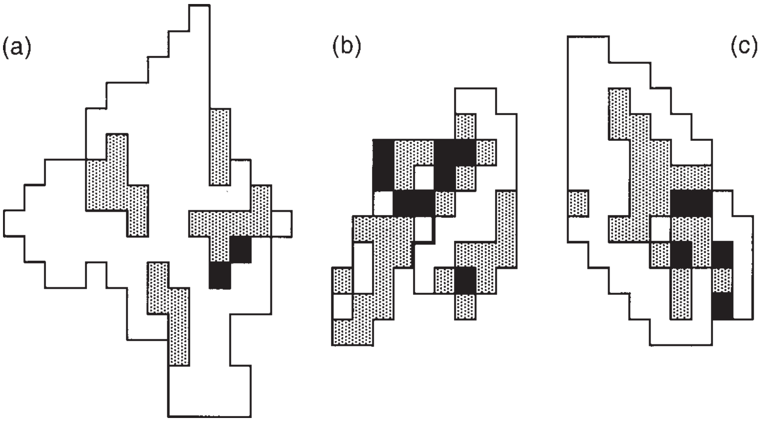

Fig. 3. Schematic representation of the spatial distribution of areas where the soil depth was ≥30 cm (filled) or 10–30 cm (shaded) in the **a,** north, **b,** east and **c,** south-east quarried areas. North is approximately to the top of each figure, and the upper shelf of the east quarry working is on the left of that figure.

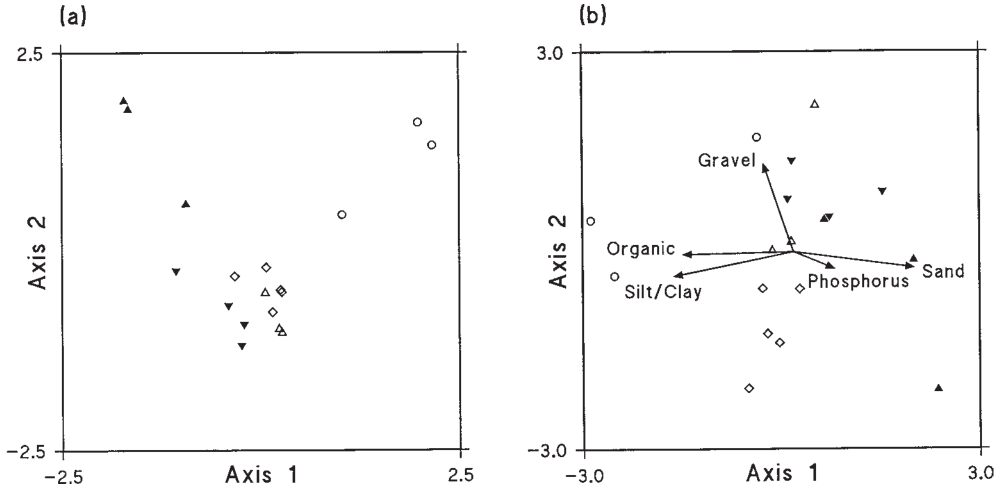

Fig. 4. Projection of the quadrats in the quarried and adjacent native areas onto axes representing the first two components of **a,** the principal components analysis of the floristic data and **b,** the redundancy analysis of the floristic and soil variables data. (o) south-east, (Δ) east and (◊) north quarry-area quadrats; (▼) long-unburnt and (▲) recently burnt native-area quadrats; (Gravel) % gravel, (Sand) % sand, (Silt/Clay) % silt and clay, (Organic) % soil organic matter, (Phosphorus) ppm available soil phosphorus.

Soil depth is indicated as not necessarily being the most important environmental characteristic associated with floristic composition, although it did vary considerably throughout the quarried area (Fig. 3), with many distinct pockets of deeper soil. Indeed, the north working has a very skeletal soil over most of its area, while the upper shelf of the east working has much deeper soil. The soil of the south-east working becomes deeper around the waterhole.

Table 2. Average importance scores for species showing statistically significant differences in abundance between the native and quarried areas, as determined by Mann-Whitney U-tests.

Species	Native area	Quarried area
Number of quadrats	7	11
More abundant in native area		
Caustis pentandra	6.0	1.7
Actinotus minor	4.7	1.8
Cyathochaeta diandra	4.1	0.4
Leptospermum trinervium	4.0	0.9
Leucopogon ericoides	3.3	0.6
Angophora hispida	3.0	0.1
Banksia oblongifolia	2.9	0.2
Boronia ledifolia	2.9	0.6
Grevillea buxifolia	2.7	0.3
Dampiera stricta	2.6	0.6
Leptospermum arachnoides	2.0	0.0
Cassytha glabella	1.6	0.0
Lomandra obliqua	1.6	0.0
Xanthorrhoea media	1.6	0.5
Eucalyptus haemastoma	1.3	0.6
More abundant in quarried area		
Andropogon virginicus	0.0	2.7
Cassinia denticulata	0.0	1.8
Eucalyptus sieberi	0.0	1.4

The ordination comparison of the quadrats from the quarried area and the adjacent native area does not show a particularly clear floristic distinction between the two data sets (Fig. 4a), the first two axes accounting for 34% of the total variation in floristic composition. This distinction corresponds to significant differences in abundance of only 18 species (12% of those in both data sets), with 15 species showing greater abundance in the native area and 3 showing lower abundance (Table 2). As noted above, there are another 16% of the species occuring only in the native area alone (Appendix 1). The most interesting pattern shown by the ordination is that the south-east quarry working is floristically no more different from the rest of the quarry than is the recently burnt native area from the long-unburnt native area. In fact, the quadrats in the long-unburnt native area are rather similar in species composition to those of the north and east quarry workings.

Much of the floristic variation that is not shown in the ordination diagram is accounted for by the distinctness of the quadrats in the east quarry working from those in the north working and in the long-unburnt native area, which are lumped together in the ordination diagram. The east quarry working is rather depauperate (Table 1), having only 37% of the total number of species found, while the other areas have 48–53% of them (excluding the introduced species from the calculations).

The redundancy analysis of the quadrats from the quarried area and the adjacent native area does not show a particularly strong relationship between the pattern of floristic composition between the areas and the measured soil variables (Fig. 4b), with the two axes shown accounting for 62% of the total sum of squares of the first two axes of the equivalent unconstrained ordination. The pattern is very similar to that shown for the analysis of the quadrats from the quarried area alone, with the quadrats from the native area perhaps having sandier soil. However, the soil characteristics do not account for the spatial heterogeneity in floristic composition of the quadrats within the native area, which must then be attributed mainly to the effects of fire.

Discussion

Our study detected a consistent pattern of plant species composition within the quarried area, with the three workings being floristically distinct. However, these areas are distinct for at least two separate reasons. The south-east working is distinct from the other two in having an abundance of exotic species, while the east working is distinct from the other two in having fewer native species. This distinction is presumably maintained by the presence of the partially unquarried ridges between the workings.

Almost all of the exotic species in the disturbed area are confined to the south-east quarry working, where many of them are quite common, especially in the deeper soil near the waterhole. The partially unquarried ridge at the north edge of this working thus forms a line of demarcation, dividing the excavated area into two distinct zones. The south-east working is only about 150 m from the nearest residential development, and it is this disturbance that is presumably the source of the exotic species.

None of the measured soil physical or chemical variables was particularly correlated with the variation in floristic composition within the quarried area. However, the soil of the south-east quarry working is different in a number of ways from that of most of the other workings, being more silty/clayey and deeper. It is presumably these differences that help maintain the abundance of the exotic species.

The almost complete absence of exotics over most of the quarried area implies that this form of human disturbance is not amenable to the rapid establishment of non-native species (at least for sandstone bedrock), whereas at least 120 native species have successfully colonized the area. A similar situation was reported by Morrison et al. (1995b) for another denuded sandstone area near Sydney. It is presumably the relatively thin and nutrient-poor nature of the soil that provides a suitable medium for the native species but not for the exotics (cf. Hannon & Evans 1963). This contrasts strongly with the situation in mined areas where topsoil is returned (e.g. sand mining), where the widespread establishment of exotics is common (e.g. Buckney & Morrison 1992, Fox et al. 1996) and soil impedance seems to affect the survival of native seedlings (e.g. Enright & Lamont 1992, Fox et al. 1996).

Assuming that the adjacent native area has been the major seed source for those plants that have colonized the quarried area (passing people are the only other likely source), then this must be the most relevant floristic comparison. There is some distinction between the plant species composition of the denuded area and the adjacent area, with 17% of the native species encountered not occurring in the denuded area and a further 10% showing a significantly lower abundance in this area. These species include trees, shrubs, herbs and grasses.

However, the distinction between these areas is not great, because the spatial heterogeneity of floristic composition within both areas is large. The native area last burnt in 1990 is quite different from the native area last burnt in 1968, and this distinction is as large as the difference between the south-east quarry working and the rest of the quarry site. This means that the long-unburnt native area is rather similar in species composition to the north and east quarry workings. The soil structure and fertility both showed no consistent differences between the native area and the quarried area, and so these variables cannot be the source of any observed differences in species composition.

The effect of fire frequency on the floristic composition of undisturbed dry sclerophyll vegetation of the Sydney region is well known (Morrison et al. 1995c, Cary & Morrison 1995). In this instance, it is not clear whether the variation in species composition in the native area is a result of the difference in the timing of the most recent fire (7 versus 29 years previously) or of differences in other aspects of fire frequency, such as the patterns of times between prior fires (e.g. shortest fire-free period). Either way, the important point is that this variation has produced an effect that is of the same order of magnitude as the difference between the quarried and unquarried areas.

However, it is the long-unburnt area that is floristically most similar to the quarried area, and this community represents an unusual state for Sydney vegetation — there are not many locations that have remained unburnt for such a lengthy period. For many of the species in this vegetation the adults will have died of old age, and these species will thus be represented in the community solely by a soil seedbank. Such species will not have been recorded in our quadrats, which sampled only the above-ground vegetation. Should a fire occur in this area in the near future, then we predict that the recorded species composition would be very different for this area, becoming much more similar to that of the more-recently burnt area. This change is unlikely to occur in the quarried area, unless there is a substantial soil seedbank of unrecorded species. It would thus be very instructive to examine the extent and composition of the soil seedbank of the three quarried areas. The possible effects of fire on revegetated areas has not been quantitatively studied in Australia, and thus remains an avenue of future scientific research (cf. Buckney & Morrison 1992).

In spite of the relative success of the native plants in colonizing the bare area, the revegetation to date can best be characterized as reclamation rather than restoration (using the terminology of Allen 1988), and the south-east quarry, with its abundance of weeds, may not even qualify for this category. However, natural vegetation is rarely allowed to establish unaided after human disturbance, and this area provides an excellent opportunity for the continued study of natural rehabilitation. Unfortunately, no previous data have been recorded for this quarry, and so it is not possible to assess the temporal trend of revegetation to date.

It is, however, possible to compare the quarry area to other examples of denuded areas that have been revegetated unaided. The most obviously relevant comparison is that with the 3 ha sandstone area at Yanderra, 110 km south-west of Sydney, which was denuded shortly before the quarry was abandoned (during the construction of the main southern railway line). Morrison et al. (1995b) reported a rather uniform species composition for their denuded area, unlike the situation observed here. There was little variation in the topography of the denuded area at Yanderra, and so this distinction emphasizes the importance of the partially quarried ridges in creating distinct floristic zones within the Jones quarry. Furthermore, at Yanderra soil depth was the principal determining factor for floristic diversity within the denuded area, whereas this factor was apparently less important in the quarry. Furthermore, 120 native species were recorded in the quarry while only 80 such species were recorded at Yanderra. This might be due to the smaller area of the quarry, making it easier for the native species to colonize from the surrounding vegetation. Nevertheless, in both cases the exotic species were confined to only one distinct section of the disturbed area, in the case of Yanderra this being the strip of land adjacent to the railway line. Thus, a nearby disturbance appears to be necessary for the colonization of weeds. All in all, the similarities probably outweigh the differences, and yet there are clear distinctions between the two revegetation patterns.

Acknowledgements

Thanks to Jennifer Cox for all of her assistance with the field work; Rod Buckney for help with the plant identifications; Narelle Richardson for helpful advice concerning the soil analysis; and Ku-ring-gai Municipal Council for permission to carry out the study on land under their care.

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Appendix: Plant species found in the quarried area and the adjacent native area.

Nomenclature follows Harden (1990–1993)
* = introduced species
+ = species found in the area

	Quarried area			Native area	
	North	East	South-east	Recently burnt	Long unburnt
FERNS					
Dennstaedtiaceae					
Pteridium esculentum			+		
Dicksoniaceae					
Calochlaena dubia		+			
Schizaeaceae					
Schizaea bifida	+		+		
MONOCOTYLEDONES					
Agavaceae					
Yucca aloifolia *			+		
Asparagaceae					
Protasparagus aethiopicus *			+		
Asphodelaceae					
Asphodelus fistulosus *			+		
Cyperaceae					
Caustis flexuosa	+	+	+		+
Caustis pentandra	+	+		+	+
Cyathochaeta diandra		+		+	+
Lepidosperma filiforme				+	
Lepidosperma laterale	+	+			
Schoenus imberbis	+			+	+

	Quarried area			Native area	
	North	East	South-east	Recently burnt	Long unburnt
Iridaceae					
Iris germanica *			+		
Patersonia glabrata	+	+		+	
Patersonia sericea	+	+		+	+
Juncaceae					
Juncus cognatus *			+		
Juncus continuus			+		
Juncus revolutus					+
Juncus usitatus			+		
Lomandraceae					
Lomandra confertifolia			+	+	+
Lomandra filiformis				+	
Lomandra glauca		+		+	+
Lomandra gracilis		+		+	+
Lomandra longifolia			+	+	+
Lomandra micrantha					+
Lomandra obliqua				+	
Orchidaceae					
Cryptostylis subulata		+			
Pterostylis concinna					+
Phormiaceae					
Dianella caerulea		+	+		+
Dianella prunina		+			
Poaceae					
Andropogon virginicus *	+		+		
Anisopogon avenaceus		+			
Aristida benthamii		+			
Avena barbata *		+			
Cynodon dactylon		+			
Danthonia sp.	+	+			+
Entolasia stricta	+	+	+	+	+
Eragrostis brownii	+				
Eragrostis parviflora			+		
Imperata cylindrica		+	+		
Panicum simile	+	+	+	+	+
Restionaceae					
Lepyrodia scariosa	+	+	+	+	+
Xanthorrhoeaceae					
Xanthorrhoea media		+		+	+
DICOTYLEDONES					
Apiaceae					
Actinotus minor	+	+		+	+
Platysace linearifolia	+		+	+	+
Xanthosia pilosa	+	+	+	+	
Asteraceae					
Ageratina adenophora *			+		
Bidens pilosa *			+		
Cassinia denticulata		+	+		
Conyza bonariensis *			+		
Hypochaeris sp. *			+		
Senecio jacobaea *			+		
Baueraceae					
Bauera rubioides	+				
Caryophyllaceae					
Saponaria officinalis *			+		
Casuarinaceae					
Allocasuarina distyla	+	+	+	+	+
Allocasuarina littoralis		+			

	Quarried area			**Native area**	
	North	East	South-east	Recently burnt	Long unburnt
Clusiaceae					
Hypericum sp.			+		
Cunoniaceae					
Ceratopetalum gummiferum		+			
Dilleniaceae					
Hibbertia aspera	+		+	+	+
Hibbertia bracteata	+	+		+	+
Hibbertia cistiflora					+
Hibbertia linearis			+	+	+
Hibbertia obtusifolia	+				+
Droseraceae					
Drosera peltata	+		+		
Epacridaceae					
Epacris microphylla	+	+	+	+	+
Leucopogon ericoides	+		+	+	+
Leucopogon microphyllus	+	+	+	+	+
Styphelia tubiflora	+			+	
Woollsia pungens	+	+	+	+	+
Euphorbiaceae					
Chamaesyce drummondii			+		
Micrantheum ericoides	+				+
Phyllanthus hirtellus		+			
Fabaceae subfam. Faboideae					
Bossiaea heterophylla		+	+	+	+
Bossiaea scolopendria	+		+	+	+
Dillwynia floribunda	+			+	+
Dillwynia retorta	+		+	+	+
Dipogon lignosus *			+		
Gompholobium glabratum				+	
Gompholobium grandiflorum			+	+	
Pultenaea elliptica	+		+	+	+
Trifolium repens *			+		
Vicia sativa *			+		
Fabaceae subfam. Mimosoideae					
Acacia falcata			+		
Acacia linifolia				+	
Acacia oxycedrus	+		+		+
Acacia suaveolens	+	+	+	+	+
Acacia terminalis	+		+	+	
Goodeniaceae					
Dampiera stricta	+		+	+	+
Goodenia bellidifolia	+		+		+
Haloragaceae					
Gonocarpus teucrioides		+			
Lauraceae					
Cassytha glabella				+	+
Myrtaceae					
Angophora hispida	+			+	+
Baeckea brevifolia			+		
Callistemon citrinus			+		
Darwinia fascicularis	+			+	+
Eucalyptus haemastoma		+		+	+
Eucalyptus oblonga		+			+
Eucalyptus sieberi		+	+		
Kunzea capitata	+			+	
Leptospermum arachnoides				+	+
Leptospermum parvifolium	+			+	
Leptospermum polygalifolium		+	+	+	
Leptospermum squarrosum	+	+	+	+	+
Leptospermum trinervium	+	+	+	+	+

	Quarried area			**Native area**	
	North	East	South-east	Recently burnt	Long unburnt
Oleaceae					
Ligustrum sinense *			+		
Oxalidaceae					
Oxalis corniculata *			+		
Pittosporaceae					
Pittosporum undulatum		+			
Plantaginaceae					
Plantago lanceolata *			+		
Polygalaceae					
Comesperma ericinum	+	+	+	+	
Polygonaceae					
Persicaria capitata *			+		
Proteaceae					
Banksia ericifolia	+	+	+	+	+
Banksia marginata				+	
Banksia oblongifolia	+			+	+
Banksia serrata	+		+	+	+
Banksia spinulosa					+
Grevillea buxifolia	+		+	+	+
Grevillea sericea	+				
Grevillea speciosa	+		+	+	+
Hakea dactyloides				+	
Hakea gibbosa		+			
Hakea sericea		+	+	+	
Hakea teretifolia	+	+	+	+	+
Lambertia formosa			+	+	+
Persoonia lanceolata	+				
Persoonia levis	+		+		
Persoonia pinifolia					+
Petrophile pulchella	+	+	+		+
Rosaceae					
Rubus sp. *			+		
Rutaceae					
Boronia ledifolia		+	+	+	+
Eriostemon australasius		+	+		+
Phebalium squameum			+		
Zieria laevigata					+
Stylidiaceae					
Stylidium productum				+	
Thymelaeaceae					
Pimelea linifolia	+	+	+		
Tremandraceae					
Tetratheca ericifolia	+				+
Tetratheca glandulosa				+	
UNIDENTIFIED					
Pteridophyte 1			+		
Cyperaceae 1					+
Poaceae 1 *			+		
Poaceae 2 *			+		
Asteraceae 1 *			+		
Unknown 1	+				
Unknown 2	+				
Unknown 3	+				
Unknown 4 *			+		
Unknown 5 *			+		
Total no. of species in the area	60	44	83	63	63
Total no. of native species in the area	59	44	57	63	63