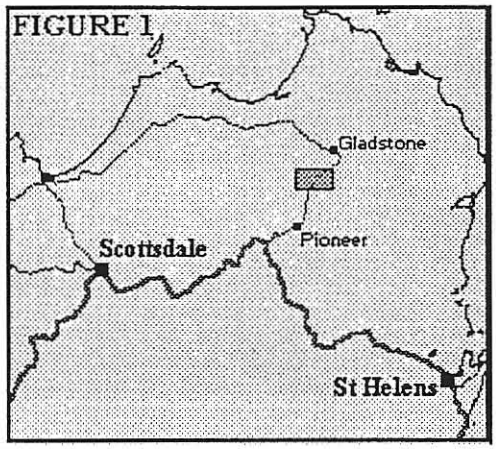
ASSESSMENT OF THE SOUTH MOUNT CAMERON MINE REHABILITATION PROJECTS

Purpose

Mineral Resources Tasmania (MRT) administers the Rehabilitation of Mining Lands Trust Fund which has been established from a small increase in Tasmanian mining royalties. The Trust Fund Committee recommended that one of the initial projects be undertaken at the former tin mining sites in north east Tasmania. MRT then requested that Environment Tasmania review the success of the rehabilitation projects undertaken at the Endurance Mine near South Mount Cameron and to provide a rehabilitation specification for future projects in the region.

Preparation of this report was seen as a unique opportunity to assess scientifically designed revegetation trials more than a decade after their establishment, and to then compare what is considered potentially achievable, based on the trial results, with the results of broadscale revegetation projects in the area.

This report focuses only on those areas of the Endurance Mine which lie to the west of the Gladstone Road. Figure 1 shows the general locality, and the area of the study (boxed).



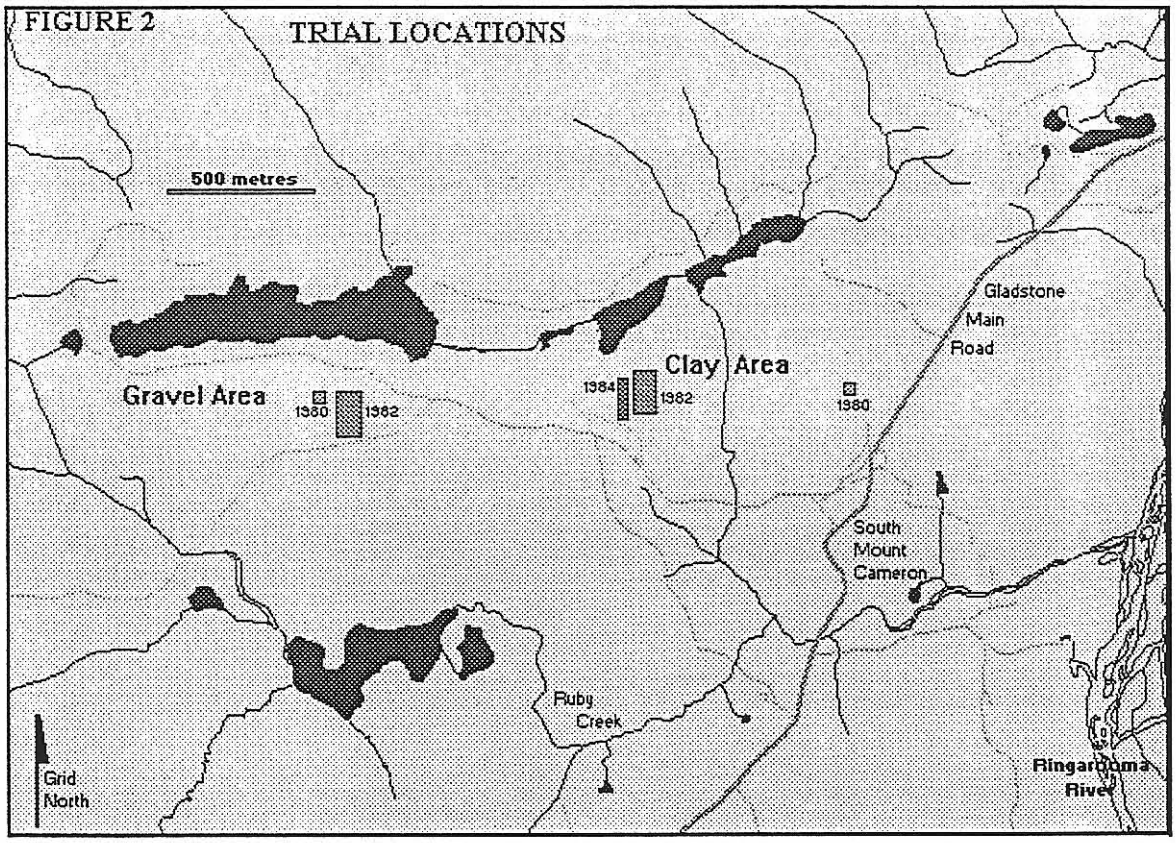
Introduction

Alluvial tin mining in north east Tasmania disturbed significant areas of granite country in the Gladstone, Pioneer and St Helens areas from the late 1800's until closure of the last mines in the early 1980's. By 1981 an estimated 2,500 ha (Crooks, 1981) had been disturbed - though today much of this area has been at least partially recolonised through natural processes.

Early attempts at revegetation included the planting of *Pinus radiata* either side of the Gladstone road by the mining companies from 1976 to 1979. The pines are still alive today, though they are generally sickly, sparse and stunted.

A number of revegetation trials were set up in the early 1980's in order to develop broadscale rehabilitation techniques which were then applied to large areas in two separate projects: the first was funded by the company BMI Mining Ltd (BMI) and the second by the Federal government via Greening Australia (GA).

Trial locations are shown in Figure 2 below. This report discusses the success of both the trials and the broadscale rehabilitation programs.



Site Description

At South Mount Cameron the tin was present in the top 50 cm of soil and was extracted by mechanical scrapers, leaving the clay subsoil exposed over large areas. The extracted material was then washed through a sluice to retrieve the tin. Fine soil particles were washed into waterways leaving behind the gravel tailings which were placed in dumps covering large areas to depths of over 6 metres.

Two types of disturbed areas are therefore present at many former tin mining areas:

- Extensive areas of heavily leached gravelly clay subsoil (Generally yellow - 10YR 7/6 with a 10% light grey mottle - 10YR 7/2 which increases with depth). Electrical conductivity is 0.05 ms/cm near the surface reducing to 0.03 ms/cm at depth (Crooks, 1981).

- The other soil type covering large areas is gravel tailings containing very few fines; particle size increases with depth and infiltration of incident rainfall is rapid.

Soil nutrient parameters:

SOIL TYPE	pH	Salinity ms/cm	N ppm	P ppm	K ppm	Ca ME%	Mg ME%	Zn ME%	Fe ME%
Clay 0.0m	4.9	.06	17	0	24	.04	.27	.12	1.19
Clay 2.0m	5.3	.03	20	2	38	.05	.83	.23	1.25
Gravel 0m	5.7	.02	17	0	20	.03	.06	.33	6.82

In short, the clay soils are infertile, erodible and relatively impermeable, while the gravel sites are infertile, stable and highly porous.

A description of the general health of the regrowth in 1996 for the various sections of the mine site is given later in this report.

1980 Revegetation Trials

During August 1980 revegetation trials were established on both gravel and clay sites at the Endurance Mine. The trials were set up jointly by the (then) Department of Agriculture and the (then) Department of the Environment (which provided the funding).

The basic aim of the trials was to compare a number of mulch treatments, and a range of native species and pasture species.

A clay site and a deep gravel site were selected for the trials (see Figure 2). The areas were cultivated with a chisel plough and fertilised at a rate of 600 kg/ha of Superphosphate and 600 kg/ha of Blood and Bone. The sites were fenced to reduce browsing (though the fence was gradually dismantled over a period of only a few weeks). A maintenance fertiliser application of Osmocote @ 219 kg/ha was given in spring 1981.

The mulches trialed included hardwood sawdust (treatment A), crushed pine bark (B), softwood chips (C), or forest litter (F). Seed mix was either a mixture of pasture species (D), or natives (E) or both.

Pasture Mix (treatment D):

Ryegrass	2 kg/ha
Brown Top	2 kg/ha
Currie Cocksfoot	3 kg/ha

Sub Clover	8 kg/ha
White Clover	2 kg/ha
Greater Trefoil	2 kg/ha

Native Seed Mix (Treatment E):

Black Peppermint	1 kg/ha
Tasmanian Ironbark	1 kg/ha
Blue Gum	1 kg/ha
Narrow Leaf Wattle (heat treated)	0.5 kg/a
Prickly Moses (heat treated)	0.5 kg/ha
She-Oak	0.5 kg/ha
Bottlebrush	0.5 kg/ha
Kunzea	0.5 kg/ha

Results

The following 2 paragraphs are a brief summary of the report of Crooks, 1981:

Pasture species established quickly after sowing with Brown Top being most prominent. Initially the unmulched plots and the forest litter plots performed best in terms of ground cover on both sites. The unmulched plots and those treated with crushed softwood bark achieved the highest crown volume scores. The natives plus pasture seed treatment achieved a low result for crown volume.

Early conclusions from the trial included that cultivation and application of fertiliser are vitally important and that mulch treatments had a negative cost benefit(Crooks, 1981).

Based on first appearances in 1996 the 1980 trial plots achieved a high overall success rate, with very few of the plots 'failing'. A 100% cover of moss and litter on most of the plots also contributes significantly to erosion control and formation of a soil A_O horizon.

In 1996 each plot was assessed for:

- Projected crown (leaf) cover expressed as a percentage of plot area,
- No. of healthy, woody species present (bryophytes and monocots were not included as their identification was generally beyond the expertise of the author).
- Top height - that is the mean height of the 3 tallest plants on the plot. Where only one plant was present its height was divided by 3.
- Species dominating the plot - based largely on area occupied, but also considering height dominance.

A summary of the results is given in Table 1.

TABLE 1:

Treatment	Clay				Gravel			
	%Cover	No. species	Top Height	ttest (%Cov.)	%Cover	No. species	Top Height	ttest (%Cov.)
D	11.7	3.3	2.1	1.000	0.0	0.7	0.1	1.000
E	88.3	5.7	5.2	0.012	***88.3***	4.0	4.7	0.007
DE	***53.3***	4.7	4.7	0.009	25.0	2.3	1.9	0.225
BD	45.0	3.0	3.2	0.248	2.0	1.7	0.5	0.321
BE	***100.0***	4.3	6.5	0.002	**66.7**	4.0	3.4	0.031
ADE	**83.3**	3.7	5.0	0.016	56.7	2.7	2.6	0.077
BDE	***91.7***	3.0	5.7	0.000	***80.0***	2.3	3.3	0.005
CDE	80.0	3.3	3.7	0.012	40.0	1.3	2.2	0.074
FDE	80.0	5.0	4.0	0.070	43.3	3.3	2.6	0.213

Bold numbers show a significantly higher crown cover than for sowing of grass seed alone (at P = 0.05), While italicised results are still significantly different at P = 0.01

The ttest column compares the population which produced the mean percentage crown cover (%Cover) for the treatment 'D' plots, with the populations which produced the mean %Cover result for each of the other tretaments respectively. The number given in the ttest column is the probability that the two populations being compared are not statistically different.

Figure 4 (see page 15) graphically compares the average results of the 1980 trial plots with results from the 1996 assessment of the broadscale rehabilitation treatments. None of the broadscale areas approach the average success of the 1980 plots - except in species diversity.

Discussion

As may be expected, plots seeded with exotic grasses alone achieved the lowest scores in all parameters. Use of mulches in combination with native seed did produce some results which are numerically higher than the results of native seed application alone - but the growth increase would not be sufficient to justify the cost of collecting and applying mulch. Pine bark appeared to be the most successful mulch treatment, showing significant growth improvements at the P = 0.01 level at both clay and gravel sites. Native seed plus grasses performed poorly at the gravel site (see discussion later on use of grasses in seed mixes).

The overall high standard achieved across the trial site is of particular interest. It is the author's contention that the most significant difference between treatments applied to the trial plots and the rest of the mine site, apart from age, is the rate and type of fertiliser applied.

The initial application of 600 kg/ha of Superphosphate plus 600 kg/ha of Blood and Bone was far higher than that typically prescribed for broadscale revegetation works today. This was followed up with an application of Osmocote 12 months later. Modern practice generally involves application of 250-300 kg/ha of fertiliser at 1 - 2 year intervals for up to 5 years.

The disturbed area is comprised of either washed gravels, or highly weathered clay subsoils (predominantly Kaolin minerals) both of which would be expected to have inherently low nutrient status and very low cation exchange capacities - consequently soluble chemical fertilisers would leach away rapidly with rainfall, leaving few nutrients bound to soil particles.

The types of fertiliser used in the trial included slow release and organic types such as Blood & Bone, and Osmocote. These fertilisers would have gradually released nutrients to establishing plants over a period of up to 12 months after application.

1982 Revegetation Trials

A further revegetation trial was established jointly by the (then) Department of Agriculture and the (then) Department of the Environment in 1982, with funding provided by Amdex Mining Ltd. The trial evaluated the following treatments:

G Native species seed (@ 1.5 kg/ha) plus Brown Top, (@ 2kg/ha)
H Native species seed (@ 3.0 kg/ha) plus Brown Top, (@ 2kg/ha)
I Native species seed (@ 1.5 kg/ha) only
J Native species seed (@ 3.0 kg/ha) only

Two areas of 160 by 60 metres were marked out to give 48 plots at each site, one on clay, the other on gravel The approximate locations are marked on Figure 2.

The ground surface was ripped at 2 metre intervals on the clay site and ploughed at the gravel site. The plots were fertilised at a rate of 300 kg/ha (clay) and 350kg/ha (gravel) with a 7:9:11 fertiliser mixture. Some erosion control structures were created at the clay site to protect the plots. Maintenance fertiliser was to be applied after 12 months at a rate of 200 - 300 kg/ha (McCambridge, 1982) though records do not confirm whether this occurred.

Each of the four treatments were replicated 12 times on a randomised design at each of the two trial areas.

The trials were subjectively assessed by the author during December 1996, some 14 years after their establishment. Each plot was located and allocated a category from 'Excellent' (dense cover of tall trees of up to 20cm diameter at breast height) to 'Poor' (similar in cover and vigour to the surrounding broadscale mine revegetation of the mid 1980's) with a '+' or '-' added to denote a better or worse example of the category. A similar set of categories and scores was developed for the gravel site taking into account its lower average plant density and vigour.

This assessment, while subjective, was done blind (*i.e.* at the time of the assessment the author was completely unaware of the treatment which had been applied to the plot being assessed).

Results

Each of the above categories was allocated a score (from 2 points for 'Poor-' to 16 points for 'Excellent+') and the totals summed for all plots of that treatment. The trial results are shown in Table 2:

TABLE 2	Total score over 12 plots			
	Clay Site	Ttest	Gravel Site	Ttest
Treatment G	53	1.000	51	1.000
Treatment H	58	0.612	58	0.506
Treatment I	**83**	0.009	55	0.663
Treatment J	**112**	0.000	**85**	0.008
Scores which differ significantly from the top row are shown in bold.				

The effect on the quality of the regrowth 14 years after sowing of not including grass in the seed mix is quite profound. Some of the plots which received treatment J supported the best examples of revegetation seen anywhere on the entire mine site.

The trial on the gravel area was compromised by recreational motorcycle use. A significant proportion of the area was, and continues to be, severely disturbed in this way. Despite this disturbance, treatment J again received a score significantly higher than the other treatments. In fact trees on some of the J plots now contain vegetation of sufficient size as to warrant a safety hazard to motorcycle riders. It is interesting to note that at the time of the 1983 assessment of these plots there was no significant difference between the treatments at the gravel site (McCambridge, 1983).

Discussion

Sowing grass seeds along with seed of natives species on sites where erosion is a potential problem has become common rehabilitation practice in Tasmania. The reasons cited are generally: rapid stabilisation of the surface soils by a mat of fine roots, addition of organic matter to the exposed subsoils which may be largely devoid of humic material, and to provide an early 'greening' of the site.

McCambridge (1983) states in his assessment of the trials that 'The results indicated that a significantly higher number of native trees had established at the clay site when seeded without grass than when seeded with grass. It was observed, however, that in the absence of grass species erosion of the site continued despite the presence of native tree species in reasonably high numbers". On re-assessment of these trials in 1987, Cartwright (1987) found that as the grasses declined due to depletion of nutrients, further recruitment of natives continued on the grassed plots.

Stabilisation of surface soils is very important to the success of a rehabilitation operation. However, a grass cover alone will not fully prevent the massive gully erosion of dispersive subsoils which tends to occur on former tin mining sites. From the above results it is clear that a grass cover which hinders establishment of natives will not enhance erosion control in the long term due to its detrimental impact upon the native species. Today treatments G and H display negligible litter cover and continue to erode, though treatment J has generally stabilised the surface soil with a mulch of litter.

At the Endurance Mine the beneficial impact of the addition of organic matter by grass growth is a moot point. Wind blasting by sediments carried on westerly winds traversing the large expanse of tailings of the western endurance has long been considered to be a major limiting factor to revegetation. (Leys & McTainsh, 1994) analysed windblown dust particles from cultivated agricultural sites and found that the bulk of this material was in fact very fine pieces of organic material and its nutrient value was found to be significantly higher than that of the surface soils left behind. It may be that a similar trend has occurred at the Endurance, as today there is negligible evidence of exotic grasses and the organic matter they may have added to surface soils, across the entire mine site. The 1980 and 1982 trial plots have shown that a healthy cover of native trees and shrubs adds considerable quantities of organic material by way of leaf litter over periods of 10 years or more.

Based on the results of these trials alone one might recommend that no exotic grass seed be included in seed mixes except on very steep erodible sites or drainage lines. However, a number of other factors must be considered.

The grass species Brown Top which was used on many of the trial plots and for the broadscale revegetation projects is said to be both persistent and aggressive in more fertile situations (Tim Duckett *pers. com.*). On the other hand the exotic grass Ryecorn has been used in numerous Tasmanian rehabilitation projects and rarely persists for more than 12 months, thereby allowing the natives to grow on without hindrance.

Rainfall may be another important factor to consider. In agroforestry situations exotic grasses have been shown to compete strongly for soil water, causing drought stress in natives even where rainfall is moderate. In higher rainfall areas such as southern and western Tasmania this may be less of a problem.

1984 Revegetation Trials

Another revegetation trial was established in 1984 to further refine a broadscale revegetation technique for the mine site. Four fertiliser regimes were tested along with two grass seed mixes with each treatment being replicated 3 times on plots which had been ripped at 2 metre intervals.

Given the results of the 1982 trials mentioned above, an attempt was made to separate the grass (which was sown between the rip lines) and the natives (which were sown on the rip lines).

A visual assessment system similar to that described above was devised for the 1984 trials. The scores and test for significance are shown below:

TABLE 3:

Brown Top + Sub Clover:	Score for each of 3 replicates			TOTALS	Ttest
Mo Superphosphate (200kg/ha)	12	6	8	26	0.435
Lime (2,500 kg/ha)	9	4	8	21	0.807
8:4:10 (200kg/ha)	6	9	9	24	0.516
No fertiliser	6	3	10	19	1.000
Porto Cocksfoot, Ryegrass, Phalaris + Sub Clover:					
Mo Superphosphate (200kg/ha)	6	9	11	26	0.234
Lime (2,500 kg/ha)	6	7	6	19	0.646
8:4:10 (200kg/ha)	6	6	10	22	0.436
No fertiliser	3	4	9	16	1.000
No significant differences to the 'No fertiliser' result were found at the P = 0.05 level.					

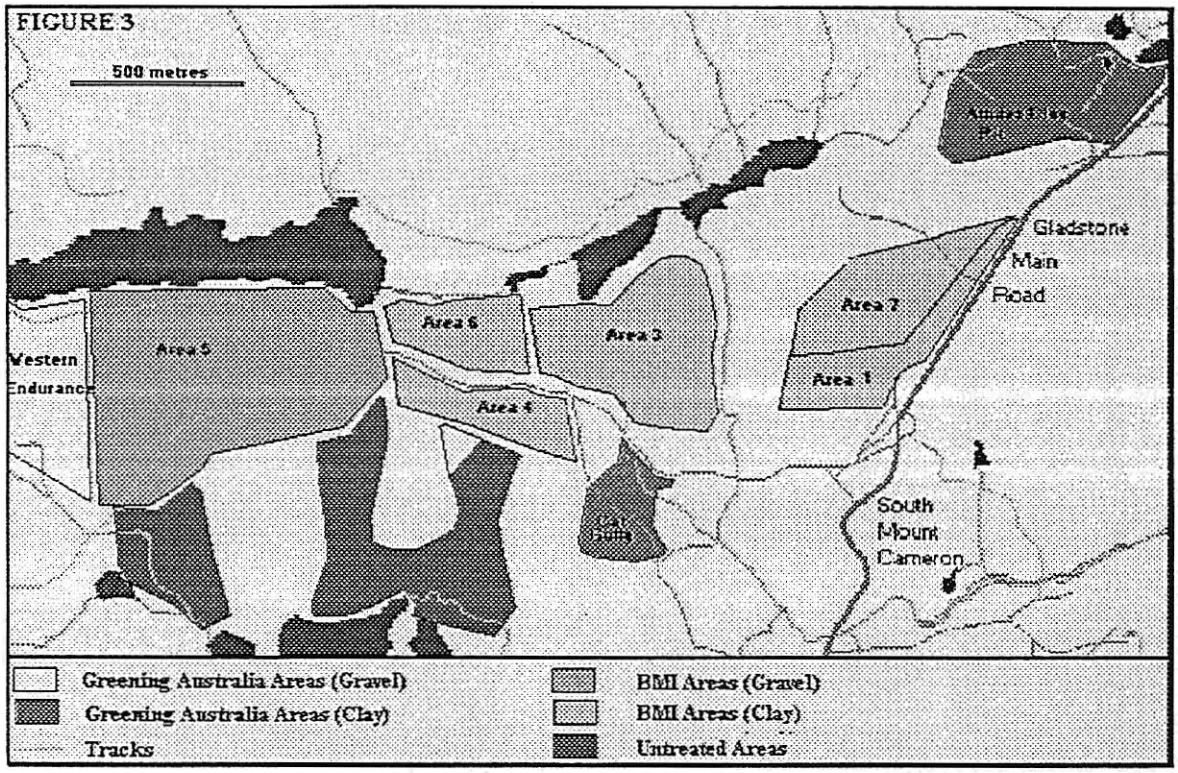
Based on the 1996 visual assessment none of the soil treatments produced any significant improvement in revegetation over the unfertilised plots (sample size was too small to attribute significance). The lime application rate would have been too low to raise the pH of the soil surface more than 0.2 - 0.3 pH points.

Brad Cartwright's unpublished report of 1987 stated that while the data showed no significant difference between the grass seed mixes "no mixed grass replicates had greater [native plant] numbers than any of the Brown Top replicates" and "There was a greater number of each species, except *E. obliqua* , where the grass cover was Brown Top rather than mixed grasses."

Judging by overall appearance, the 1984 trial area generally exhibits marginally better growth, density and diversity than the surrounding broadscale mine revegetation of the mid 1980's. However, none of the plots have achieved the excellent growth seen on the nearby 'J' treatment (no grass seed) plots of 1982 or the 1980 trial plots on clay.

Broadscale Revegetation 1986 (Company funded)

The results of the abovementioned trials were used in 1985 to develop a broadscale revegetation program for the Endurance Mine. The program treated some 122 ha over a four year period commencing in Spring 1985, focussing on areas which were actively contributing to sediment load in watercourses and areas which were visible from the Gladstone Road (See Figure 3). The work was carried out by Boral BMG Resources with the Departments of Agriculture and Environment advising. The project was funded by the former Mining Lease holder BMI Mining Pty Ltd (BMI).



The treatments applied were as follows:

5 cm

CLAY SITES

- Contour ripping to 50cm depth at 3m intervals.
- An 8:4:10 chemical fertiliser was spread over the entire area at the rate of 200 kg/ha using a drop spreader.
- Brown Top grass was sown between the rip lines (approx 2.7m wide strip) at 5 kg/ha (of area treated). The inter rip area was then lightly harrowed (with a normal harrow turned upside down).
- 6 months later native seed was sown along the rip lines (0.3m wide strip) at 3 kg/ha (of area treated).
- Areas with pre-existing natural regrowth were treated by spreading a native species seed and fertiliser mix only on 1 metre strips located in sparsely vegetated areas (to avoid damaging vegetation). Approximately 20% of each area with pre-existing natural regrowth was treated in this manner.
- Diversion banks were established where appropriate and seeded with Brown Top.

GRAVEL SITES

Subject to a once only treatment (this area was not disturbed or worked by BMI).

- Native species seed and fertiliser were spread in one metre wide strips at approximately 2 metre intervals perpendicular to the prevailing wind direction (*i.e.* north-south). The seeded area was then lightly harrowed.

SEED MIX

Common name	**Proportion by weight**
Natives Mix	
Sunshine Wattle	10%
Silver Wattle	10%
Narrow Leaf Wattle	16%
Wirilda	10%
Prickly Moses	12%
Bull-Oak	3%
Dwarf She-Oak	3%
Black peppermint	15%
Brown Stringy Bark	7%
Black Gum	3%
Tasmanian Ironbark	3%
Kunzea	4%
Manuka	4%
Grass Mix	
Brown Top grass	100%

MAINTENANCE

Browsing control using 1080 poison was to be undertaken.

A progress assessment to assess maintenance requirements was scheduled for Autumn 1988, though the company committed only to replanting and refertilising 'a total maximum of 5 hectares' (Percival, 1986)

Greening Australia (GA) Broadscale Rehabilitation Project 1985-86

The following description of the project has been condensed from the report by Singline, 1986.

The South Mount Cameron Project commenced in October 1985 and finished in November 1986. The project received Community Employment Program funding for 42 field workers (6 months each) plus non-labour funding of $115,000. Approximately 150 hectares were rehabilitated

The aim of the project was to establish a stable land surface supporting a self-sustaining vegetative cover comprised of mainly local native tree species, as well as providing retrenched tin miners with new and useful skills.

The large workforce made possible the collection of large quantities of local seed and the establishment of a plant nursery.

CLAY SITES

Generally as for the BMI treatments detailed above with the fertiliser application rate increased to 500 kg/ha (7:6:0). Extra care was taken to avoid encroachment of grass seeds onto the rip lines.

Erosion control on clay sites was considered a key factor in rehabilitation success. Care was taken to reduce slopes and divert runoff away from treated areas. Hay was applied (but not fixed) to long sloping banks at a rate of one bale per $25m^2$. Further erosion control works were constructed (such as diversion drains, and laying of hay and cut scrub in drainage lines) by hand as problems arose. These methods were found by Singline (1986) to have been effective.

GRAVEL SITES

The only site preparation was the construction by dozer of windrows of gravel at 100m intervals perpendicular to the prevailing winds. Slash was placed on top of the windrows to further increase the windbreak height. On gravel sites the fertiliser application rate was halved to 250 kg/ha.

Due to poor grass germination a second treatment of gravel areas was performed with the grass seeding rate increased to 10 kg/ha.

MAINTENANCE

During spring all areas which had less than 50% vegetation cover received a full second treatment. Riplines in which excessive grass had established were treated with herbicide prior to the second sowing. Areas with greater than 50% cover received a second application of fertiliser only (50/50 mix of 8:4:10 and 3:6:8).

SEED MIX

The seed mix varied slightly based on local conditions but included all of the species mentioned in the BMI section above with the following additions:

Common name	**Proportion by weight**
Coastal Wattle	2.5%
Sunshine Wattle	1.0%
Cootamundra Wattle	1.5%
Cutting Grass	10%
She-oak (drooping)	2.0%
Cabbage Gum	1.5%

White Gum	0.3%
Woolly Tea Tree	0.5%
Scented Paperbark	2.5%

Use of local seed was considered important to the project's success. The seed was bulked tenfold with dry sawdust and applied at a rate of 4 kg/ha of rip line treated. Many seedlings from the autumn sowing died during winter frosts, though the spring sowing was found to produce a lower germination rate.

Seedlings were planted in May 1986 along the rip lines. Each seedling was covered with an inverted plastic (bio-degradable) beaker with its end removed, and each received a fertiliser pellet. Many of the seedlings were planted into a lump of imported topsoil.

Browsing by wildlife was found to be a major long term maintenance consideration and a 1080 poisoning campaign was commenced. Following adverse comment about the use of 1080, poisoning was replaced by shooting campaigns.

1996 Assessment of the Broadscale Rehabilitation

An assessment of the Endurance Mine rehabilitation projects was undertaken by Environment Tasmania in order to compare the broadscale treatments to the standard which was found to be potentially achievable from the trials.

Procedures

A rapid assessment method based on randomly located plots of 7 by 3 metres (chosen to allow comparison with the 1980 trial plots) was devised to determine the relative success of the various treatments applied at the Endurance Mine.

The mine site was divided into relatively homogenous areas of around 10-30 hectares each, based on the soil type and the agency responsible for rehabilitation (see Figure 3). Assuming that the quality of the revegetation within each area was randomly spread, plots were located at 80 metre intervals along transects bisecting the areas. Plots were initially located a random distance (1 - 20m) alternating left or right of the transect, however this procedure was later ceased as it was not considered to add significantly to the 'randomness' of the plot locations. Plots were then located on the transects with the plot point always being the north east corner of the plot.

Each plot was assessed as described for the 1980 trial plots.

Results

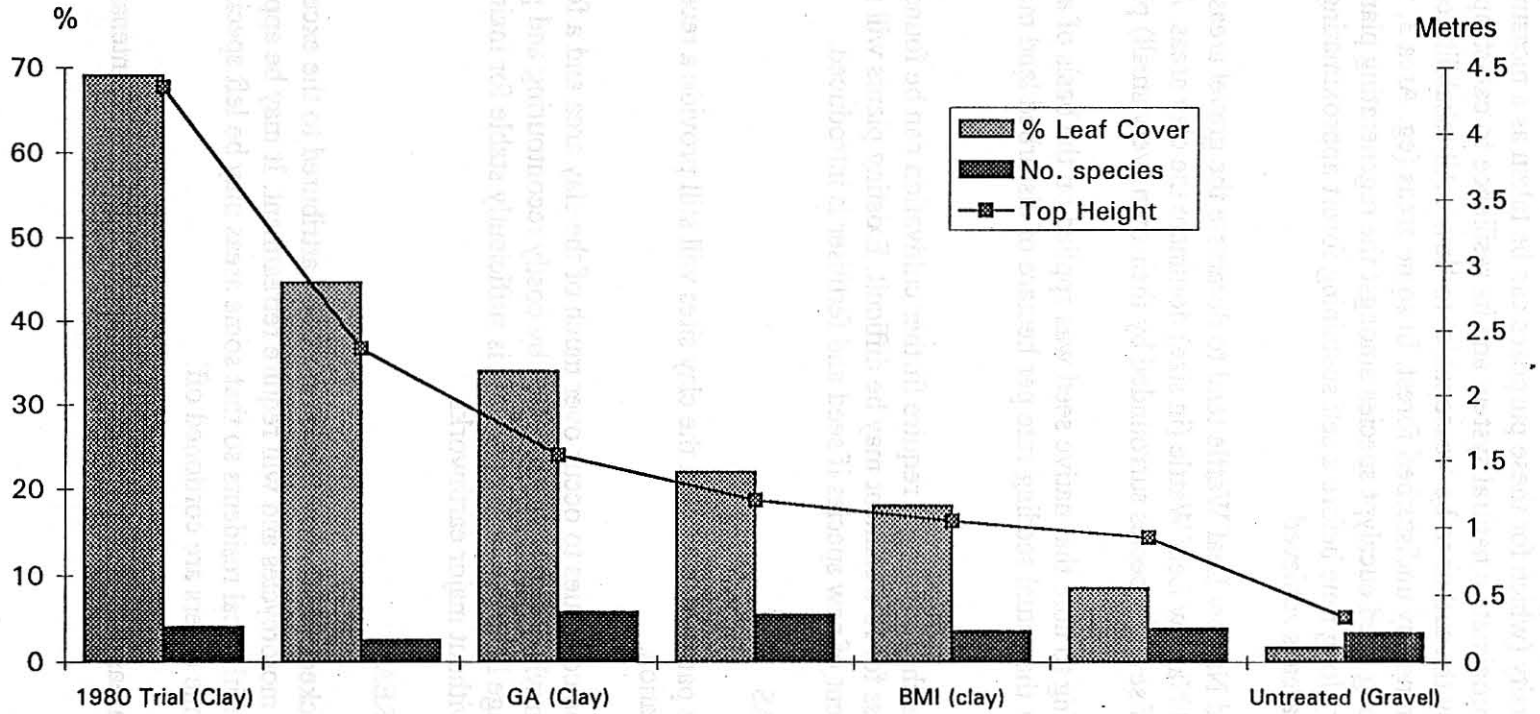
Figure 4 shows the mean results from the rapid assessment for the areas treated by BMI and Greening Australia (GA). The mean results from the 1980 trial plots are included for comparison (failed 1980 treatments are included in the means). The 1980 plot results give

an indication of the height and density of regrowth which can be achieved after 16 years growth.

The GA South Mount Cameron Rehabilitation was described as a "Complete success" by Singline, 1993.

FIGURE 4

ASSESSMENT OF ENDURANCE MINE REHABILITATION WORKS - 1996



Discussion:

The author's overall impression is that, given the inhospitability of the site, the stocking (density of plants) is satisfactory though health and vigour is low with the exception of areas immediately adjacent to the Gladstone Road (which received special attention). Species diversity (which for these purposes can be taken as a measure of an ecosystem's ability to approximate a natural system and its resilience to catastrophe) is generally considered by the author to be 'reasonable' to 'low'. All rehabilitated areas display lower diversity than nearby undisturbed forest. In some areas (eg. Area 3, western endurance) the lack of long lived eucalypt species amongst the regenerating plants indicates that it may be a very long time before a self sustaining forest approximating the surrounding undisturbed area is achieved.

Bull-Oak and Narrow Leaf Wattle tend to dominate the gravel areas while Kunzea (in number) and Narrow Leaf Wattle (in size) dominate the clay areas. A number of mature specimens of several species surrounded by their own (very small) progeny are evident.

It is interesting to note that native seed was applied on the basis of area of ripline treated, meaning that the actual seeding rate per hectare of disturbed land may have been as low as 1 kg/ha.

Near bare patches which will require further cultivation can be found across the mine site, though access for re-treatment may be difficult. Existing plants will now provide shelter for recruitment of new species if seed and fertiliser is introduced.

CLAY AREAS

Smaller bare patches evident on the clay sites will still provide a receptive seedbed with minor cultivation.

Sheet erosion continues to occur over much of the clay area and a few sites display major gully erosion which will require control by costly recontouring and pegging of geotextiles along drainage lines. Generally the area is sufficiently stable for maintenance treatments to be applied without major earthworks.

GRAVEL AREAS

Large unstocked gravel areas can generally be attributed to the excessive use of recreational motorcycles and will require retreatment. It may be appropriate to hold some discussions with local residents so that some areas may be left specifically for recreational purposes while others are cordoned off.

The gravel areas with a reasonable stocking are in need of maintenance fertiliser application.

Conclusion

Revegetation trials in the South Mount Cameron area dating to 1980, 1982, and 1984 were assessed in order to evaluate a variety of revegetation techniques. More than a decade later significant differences exist between some of the treatments.

A rapid assessment method was devised to allow comparison of surrounding revegetation projects to the trial results. The average standard of regrowth on the trial plots is higher than that of broadscale revegetation areas. The author considers this difference to be largely attributable to the following factors which were discussed above:

- Lack of adequate maintenance fertiliser application.
- Suppression of native plants due to competition with exotic grasses.
- Low native seed application rates per hectare of disturbed area.
- Failure to supply nutrients in a slow release form.
- The age of the regrowth (*ie* the trials are 2 - 7 years older than the broadscale regrowth).

Recommendations:

Its is recommended that aerial photographs be used to divide the area into the following categories:

1. Untreated or failed areas

2. Sparsely vegetated areas

3. Revegetating areas requiring no further treatment.

The following treatments are recommended for application to the respective areas:

Treatment for Category 1 areas

CLAY SITES

- Cut off drains to be installed upslope of all sloping areas which are to be rehabilitated. Existing but stable erosion gullies to be seeded or lined with seed bearing brush, where available. Depressions to be drained by shallow parabolic drains. Major drains to be lined with a geotextile membrane and sown with Ryecorn at 15 kg per ha of drain area. Seed bearing slash to be placed in drains where available.

- Actively eroding gullies to be filled in and re-shaped. Parabolic drains lined with a geo-textile membrane and sown with Ryecorn are to be constructed in order to carry runoff across and away from these areas.

- The entire area to be contour ripped to at least 50cm depth at 3m intervals while the soils are dry.

- A combination of 8:4:10+Mg chemical fertiliser @ 200 kg/ha and Blood & Bone @ 200 kg/ha to be spread over the entire area. Given the area requiring treatment aerial spreading should be considered.

- The entire area to be sown with locally collected native seed @ 3kg/ha, in the proportions described below. On steeper sites this seed should be applied via hydro-mulching or hydro-seeding. The sowing should be undertaken in mid to late autumn after the onset of wetter weather. (Wattle and Kunzea seed to be heat treated prior to sowing).

- On sloping sites (> 15%) or areas which display evidence of significant water movement, Ryecorn to be sown at a rate of 10 kg/ha of area treated (or 1 kg per 500m) to a strip between the rip lines of no more than 2 metres in width. These areas should then be hydro-mulched or hydro-seeded with the native seed mix.

- The inter rip area to be lightly harrowed.

GRAVEL SITES

- No erosion prevention works or ripping are required.

- Where large and exposed areas of bare tailings are to be treated. Windrows of tailings at least 50 cm high and perpendicular to the prevailing winds to be constructed by dozer at 50 metre intervals over the windward half of the area (this would be counter productive at the western endurance as revegetation has commenced).

- Otherwise as for clay sites. Seed mix as for clay sites.

SEED MIX

Common name	**Proportion by weight**
Sunshine Wattle	8%
Coastal Wattle	8%
Silver Wattle	10%
Narrow Leaf Wattle	15%
Banksia	10%
Bull-Oak	4%
She-Oak (Drooping)	3%

Black peppermint	10%
White Gum	5%
Cabbage Gum	5%
Tasmanian Ironbark	5%
Kunzea	10%
Manuka	4%
Scented Paperbark	3%

The seed mix is weighted toward those species which have proven to be hardy colonisers at the Endurance Mine, particularly those which have nitrogen fixing capabilities. A number of other species which may be successful in specific niche environments (eg Paperbark in wet areas) are included for increased diversity. One general seed mix is prescribed for simplicity.

MAINTENANCE PROGRAM

- Browsing control through licensed shooting to be considered

- 6 monthly erosion inspections of rehabilitated areas to be undertaken for the first 18 months after sowing. Any significant erosion events to be repaired immediately either manually or via sensitive use of a backhoe if necessary. Pegging of a geotextile membrane may be required after the earthworks are completed and the area should then be sown with a combination of Ryecorn, native seed and fertiliser (as per the original application rates).

- The laying of seed bearing tea tree slash to be undertaken in areas showing minor erosion problems.

- A maintenance application of fertiliser at the same rate as the initial application is to be undertaken 12 months after sowing. Further applications of fertiliser 3 years and 5 years after sowing to be undertaken as considered necessary following inspection. Aerial application to be considered given the large areas being treated.

- After sufficient growth has occurred to provide shelter and a litter cover at ground level (3 years plus) an enrichment planting program should be commenced for species which occur in the area naturally, but were not included in the original seed mix and are known to have poor seed dispersal characteristics. This will ensure that the regenerating forest is a naturally diverse and resilient ecosystem. A dedicated nursery and seed collection crew in north east Tasmania operating over a period of up to 5 years may be required to supply the seedlings for this process.

- Seedlings to be grown should be selected from a list of species known to occur naturally in the area surrounding the rehabilitation site, the author has found the following to be present in the vicinity of the Endurance Mine:

DAMP AREAS:

Black Gum
Boronia*
Cutting Grass*
Milkmaids*
Parrot Peas
Prickly Moses
Purple Iris*
Rice flower*
Small Leaved Melaleuca
Woolly Tea Tree

DRY AREAS:

Blue Berry*
Brown Stringy Bark
Grass Tree
Guitar plant
Hakea spp*
Saggs*
'Scruff' Wattle
Spreading Wattle
Trigger Plant*

* Species marked with an asterisk are members of genera from which Western Australian species have been shown to benefit significantly from smoke treatment of seed (Dixon *et al*, 1994). Preliminary (as yet unpublished) work in Tasmania indicates that some Tasmanian species also respond positively to smoke treatment of seed and this phenomena is likely to be widespread (though variable) across a wide range of species (David Keith, *pers. comm.*). As smoke treatment is relatively inexpensive it is considered worthy of trial in mine rehabilitation programs, particularly for species which are otherwise difficult to germinate.

Treatment for Category 2 areas

- The entire area to be fertilised twice with a 12 month period between applications @ 200 kg/ha 8:4:10+Mg chemical fertiliser combined with 200 kg/ha Blood & Bone.

- Stable erosion gullies to be seeded or spread with seed bearing brush whereavailable. Actively eroding gullies to be filled in, re-shaped and provided with stable drains (lined with geotextile and sown with Ryecorn where necessary).

- Unstocked patches to be cultivated either manually or via sensitive use of a backhoe with toothed bucket or tractor drawn harrow and sown with the native seed mix as for category 1 areas at 3 kg/ha of area treated (or 30 grams to an area of 10 x 10 metres).

- Ryecorn seed will not be required in the seed mix unless the 'patch' is large and erosion is evident.

- When sufficient shelter is available, planting of seedlings of a variety of species as described for the Category 1 treatment above to be undertaken.

Author

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Botanical Names Index

Common Name	Botanical Name
EXOTIC GRASSES:	
Brown Top	*Agrostis tenuis*
Currie Cocksfoot	*Dactylis glomerata*
Greater Trefoil	*Lotus pedunculatus*
Porto Cocksfoot	*Dactylis glomerata*
Ryecorn	*Secale cereal*
Ryegrass	*Lolium perenne*
Phalaris	*Phalaris aquatica*
Sub Clover	*Trifolium subterraneum*
White Clover	*Trifolium repens*
NATIVE SPECIES:	
Black Gum	*Eucalyptus ovata*
Black Peppermint	*Eucalyptus amygdalina*
Blue Berry	*Dianella revoluta*
Blue Gum	*Eucalyptus globulus*
Boronia	*Boronia spp.*
Brown Stringy Bark	*Eucalyptus obliqua*
Bull-Oak	*Allocasuarina littoralis*
Cabbage Gum	*Eucalyptus pauciflora*
Coastal wattle	*Acacia sophorae*

Cootamundra Wattle	*Acacia baileyana*
Cutting Grass	*Ghania grandis*
Dwarf She-Oak	*Allocasuarina monilifera*
Grass Tree	*Xanthorea spp.*
Guitar plant	*Lomatia tinctoria*
Hakea	*Hakea spp.*
Kunzea	*Kunzea ambigua*
Manuka	*Leptospermum scoparium*
Milkmaids	*Burchardia umbellata*
Narrow Leaf Wattle	*Acacia mucronata*
Parrot Peas	*Dillwynia spp.*
Prickly Moses	*Acacia verticillata*
Purple Iris	*Patersonia spp.*
Rice flower	*Pimelea spp.*
Saggs	*Lomandra longifolia*
Scented Paperbark	*Melaleuca squarrosa*
'Scruff' Wattle	*Acacia stricta*
She-Oak (Drooping)	*Allocasuarina stricta*
Silver Wattle	*Acacia dealbata*
Small Leaved Melaleuca	*Melaleuca gibbosa*
Spreading Wattle	*Acacia genistifolia*
Sunshine Wattle	*Acacia terminalis*
Tasmanian Ironbark	*Eucalyptus sieberi*
Trigger Plant	*Stylidium gramminifolium*
White Gum	*Eucalyptus viminalis*
Wirilda	*Acacia retinoides*
Woolly Tea Tree	*Leptospermum lanigerum*
Yellow Bottlebrush	*Callistemon pallidus*

References:

Cartwright, B.D., 1987, Revegetation trials at South Mt Cameron north east Tasmania, Department of Environment & land Management, unpublished internal report.

Crooks, R.D., Richley, L.R., Thompson, R.P., Stackhouse, K.M., 1981, Revegetation of alluvial Tin mining areas in north east Tasmania, Department of Environment & Land Management internal Rehabilitation Report No. 81/4.

Dixon, K.W., Roche, S., Pate, J.S., 1994, The promotive effect of smoke derived from burnt native vegetation on seed germination of Western Australian plants, Oecologia (1995), 101:185-192, Springer-Verlag.

Ducket, Tim, (*pers. comm.*), Rehabilitation Consultant, Land Management & Rehabilitation Services Pty Ltd, Phone (03) 6231 1509.

Keith, David, (*pers. comm.*), Botanist, Parks & Wildlife Service, Phone (03) 6233 6184.

McCambridge, J., 1982, Revegetation trials - Amdex Mining Ltd. - South Mt. Cameron, Department of Environment & Land Management internal Rehabilitation Report No. 82/2.

McCambridge, J., 1983, Rehabilitation Report Number 83/27, Department of Environment & Land Management internal report.

Percival, D. W., March 1986, Rehabilitation programme at South Mt. Cameron N. E. Tasmania, BMI Mining Ltd. (Report submitted to Department of Environment & Land Management).

Leys, J., McTainsh, 1994, Soil loss and nutrient decline by wind erosion - cause for concern, Australian Journal of Soil and Water Conservation Voi. 7 No. 3 pp30-35, Soil and Water Conservation of Australia Inc.

Singline, R., November 1986, The final report of the Greening Australia South Mount Cameron mine rehabilitation project, Greening Australia, Hobart.

Singline, R., 1993, The final assessment of the South Mount Cameron mine rehabilitation project, Greening Australia.