



**ECOSYSTEM FUNCTION ANALYSIS
MONITORING REPORT 2009
PAD 19, OLD TRAFLAGAR DUMP
& RADIO HILL**

2009

Final Report

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Final Report:
29/1/2010

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Executive Summary

Infiltration and nutrient cycling levels of all the transects within the Pad 19 area decreased in 2009, however the condition of Transects 2 and 3 appears to be improving. Both transects recorded an increase in stability and the banks and troughs remain intact. They also both contain a good level of plant density and high species diversity, even having greater species diversity levels than the analogue site.

Both transects within the Old Trafalgar Dump area (commonly referred to as OTD), recorded a decrease in infiltration and nutrient cycling levels. Transect 1 also displayed a decreased level of stability. Biodiversity of Transect 1 was good with high plant density and species diversity despite the worsening conditions.

All three of the Radio Hill transects had increased levels of stability yet both infiltration and nutrient cycling decreased. Vegetation within the transects has improved with increasing species density and species diversity levels. Species density of Transects 1 and 2 even exceeded density levels of the analogue site. The area near Transect 3 has been subject to high levels of erosion, with several berms in the area becoming breached causing significant tunnelling and water run off.

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1 Introduction

1.1 Pad 19

Pad 19 is located near to the Environmental Offices, on a western/south-western aspect. In 2006, Pad 19 was ripped and shaped with a D9 Dozer.

In 2007, three transects were established at Pad 19. GPS coordinates (GDA94) are:

- **Transect 1:** 51 J 0357563E 6595691N
- **Transect 2:** 51 J 0357483E 6595801N
- **Transect 3:** 51 J 0357248E 6595911N

Name: Pad 19

Established: 2006

Date EFA established: January 2007

Number of Transects: 3

Monitoring Schedule: January

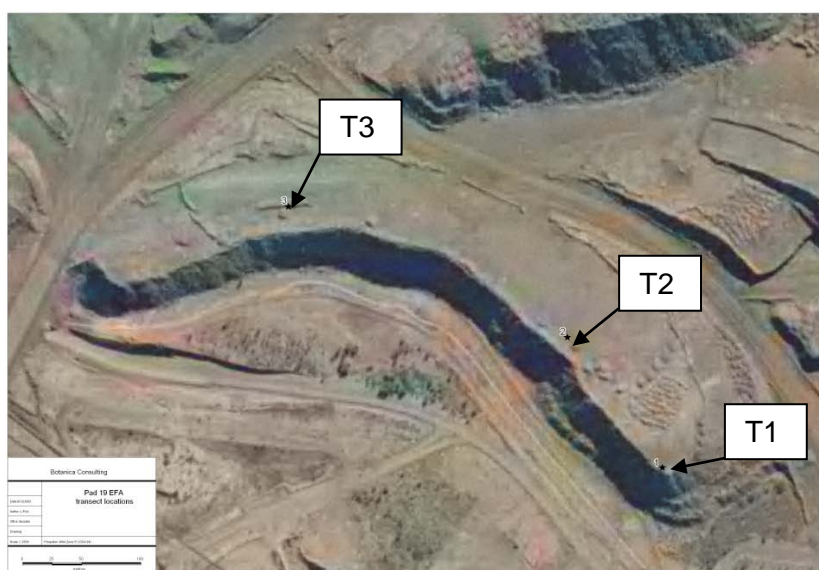


Figure 1: Pad 19 Location Maps.

1.3 Radio Hill

Radio Hill is located within the Open Pits area, on a western/south-western aspect. In 2006, Radio Hill was rehabilitated with a D9 Dozer. In 2007, three transects were established at Radio Hill. GPS coordinates (GDA94) are:

- **Transect 1:** 51 J 0358090E 6594514N
- **Transect 2:** 51 J 0358075E 6594369N
- **Transect 3:** 51 J 0357923E 6594324N

Name: Radio Hill

Established: 2006

Date EFA established: January 2007

Number of Transects: 3

Monitoring Schedule: January

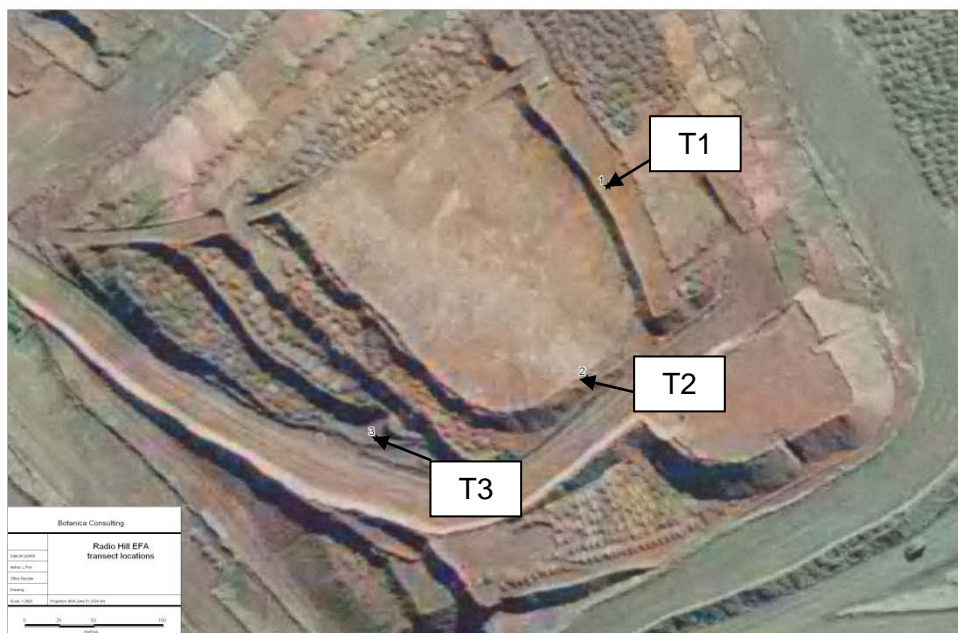


Figure 3 : Radio Hill Location Map.

2 Methods

2.1 Background

Ecosystem Function Analysis (EFA) is a field monitoring method and dynamic assessment system, developed by the Commonwealth Scientific and Industrial Research Organisation (CSIRO), which has been adapted to suit a range of diverse environments from rangeland ecosystems through to mine site rehabilitation. The method draws on the use of indicators and allows the collection of data, to determine and assess the functional status of the ecosystem components and landscape. The data provides an indication of a rehabilitated site's ecosystem development in relation to the surrounding native landscape (analogue site) and can be used to determine whether an ecosystem is evolving properly. An analogue site is an area of native landscape chosen to represent values typical of the landscape surrounding a mine.

EFA consists of landscape function analysis and measures of vegetation composition and habitat complexity. An EFA assessment is carried out on a transect running down a slope which follows the line of resource flow, for example, a rangeland hill slope, Tailings Storage Facility (TSF) batter or Waste Rock Landform batter. The loss and retention of resources down the slope is vital to consider as this dictates the functioning of the landscape. The topography of the slope (smooth or undulating), the nature of the soil (erodible or rocky) and the presence or absence of obstructions (eg plants) may affect the retention and loss of resources down the slope.

2.2 Landscape Function Analysis

Landscape Function Analysis (LFA) examines the flow and availability of resources within an ecosystem. Rehabilitated features on waste rock landforms are characterised initially by a 'bank and trough' pattern due to ripping (Figure 4). The bank is a 'source' from which resources flow away, whilst the trough is a 'sink' which tends to receive and collect resources. For an analogue site the sink categories are called 'patches' (resource accumulation zones), whilst the source categories are called 'inter-patches' (zones where resources such as water, soil materials and litter are freely transported). The analysis is conducted along a linear transect (up to 50m) and a detailed soil assessment is carried out in sub-sections of the transect (up to 1m long).

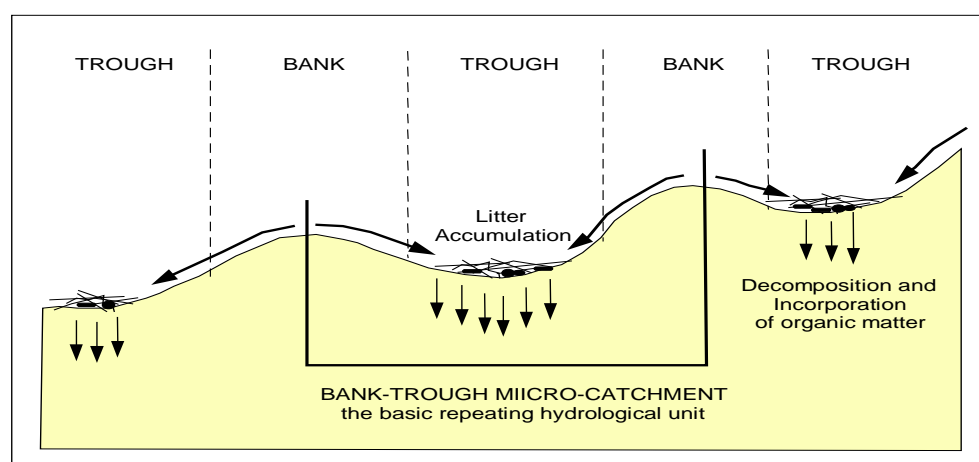


Figure 4: The bank and trough system characteristic of a newly rehabilitated landscape (Tongway & Hindley, 2004).

Measurements of the length of each bank and trough along each transect from the 0m point (located at top of slope) are recorded to develop a landscape organisation index. At the patch zones or troughs, the 'patch width' is assessed to a break in the bank where resources are being lost down slope. The width of the patch is centred on the transect line and is measured to a maximum of 5m each side (up to 10m).

Soil Surface condition is conducted on at least three replicates for each bank or trough category. The soil surface condition assessment examines eleven soil features (Table 1) and are used to determine the quality of each category in relation to stability, nutrient cycling and infiltration (Figure 5).

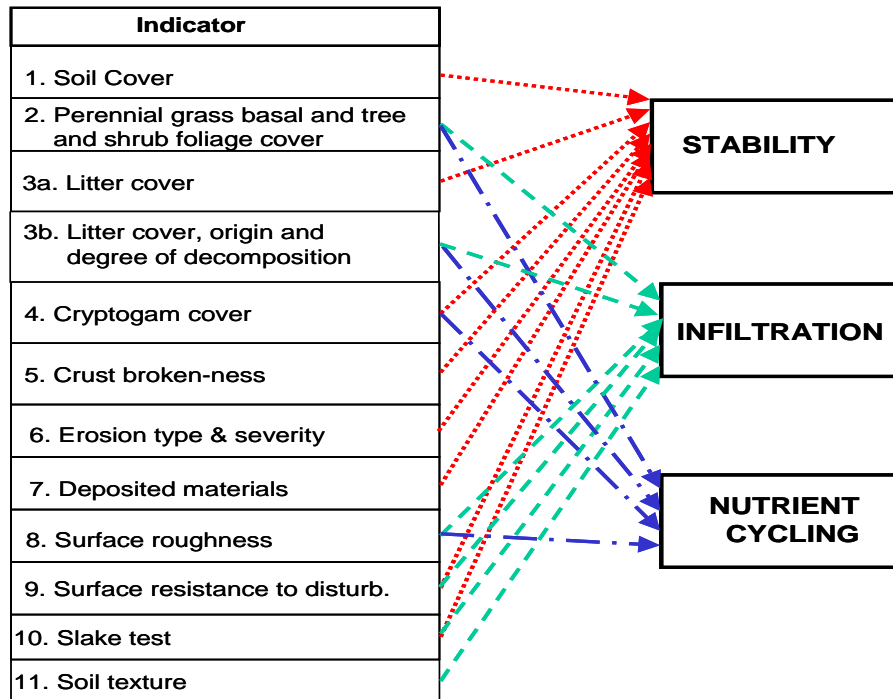


Figure 5: The contribution of soil surface indicators to stability, infiltration and nutrient cycling (Tongway & Hindley, 2004).

Table 1: Eleven Indicators of soil surface condition for the landscape assessment (Tongway & Hindley, 2004).

Indicator	Surface Feature Assessed	Score
Rainsplash Protection/ Soil Cover	Assess the degree to which the surface cover and projected plant cover ameliorate the effect of raindrops impacting on the soil surface. Assess susceptibility to erosion.	1 (low)-5 (high)
Perennial Basal Cover	Estimate the basal cover of perennial grass and/or the density of canopy cover of trees and shrubs. Assess the potential biomass for nutrient cycling	1 (low)- 4 (high)
Litter Cover	Assess the amount, origin and degree of decomposition of plant litter. Assess the soil organic matter component and degree of incorporation in the soil.	1(low) -10 (high)
Cryptogam Cover	Assess the cover of cryptogams (algae, fungi, lichens, mosses, liverworts and mycorrhizas) visible on the soil surface. The presence of cryptogams is a positive indicator of surface stability.	1(low) – 4 (high)
Crust Broken-ness	Assess to what extent the surface crust is broken. Assess crust stability and susceptibility to erosion.	1 (high) – 4 (low)
Soil Erosion Type and Severity	Assess the type and severity of recent/current soil erosion.	1 (high) – 4 (low)
Deposited Materials	Assess the nature and amount of alluvium transported to and deposited on the query zone.	1 (high) – 4 (low)
Soil Surface Roughness	Assess the surface roughness for its capacity to capture and retain mobile resources such as water, propagules, topsoil and organic matter.	1 (low) – 5 (high)
Surface Nature	Assess the ease with which the soil can be mechanically disturbed to yield material suitable for erosion by wind or water. Assess the impact that stress will have on the surface.	1 (low) – 5 (high)
Slake Test	Classify the texture of the surface soil and relate this to permeability. Assess the coherence of the soil when it is wet.	1(low) – 4 (high)

2.3 Vegetation Dynamics

From the 0m point of each transect, the vegetation dynamics of a 10 x 10 metre quadrat to the left-hand side of each transect is assessed. The projected plant cover, density, species density and species health was observed and noted.

2.4 Data Analysis

Data obtained from the assessment is entered into an Excel workbook developed by CSIRO which calculates the proportion of the slope covered by different landscape zones. Stability, infiltration and nutrient cycling indices are calculated for each zone from the scores noted during the soil surface condition assessment. Average infiltration, nutrient cycling and stability scores over the proportion of the landscape are determined for the analogue and rehabilitated areas.

2.5 Rainfall Data

The average annual rainfall is an important factor in EFA methodology. Rainfall affects vegetation growth which in turn affects the stability, nutrient cycling and infiltration of the site.

The climate of Kalgoorlie-Boulder is arid, which is characterized by cool winters and hot summers with rain falling in both seasons. Rainfall in the summer months is associated with degenerating cyclonic depressions which are characteristic of a transitional climatic zone from central arid lands to conditions related to north western coastal areas. Rainfall figures for Kalgoorlie-Boulder from 2000 to 2008 and from January 2008 to December 2008 are as follows (Figure 6 and Figure 7):

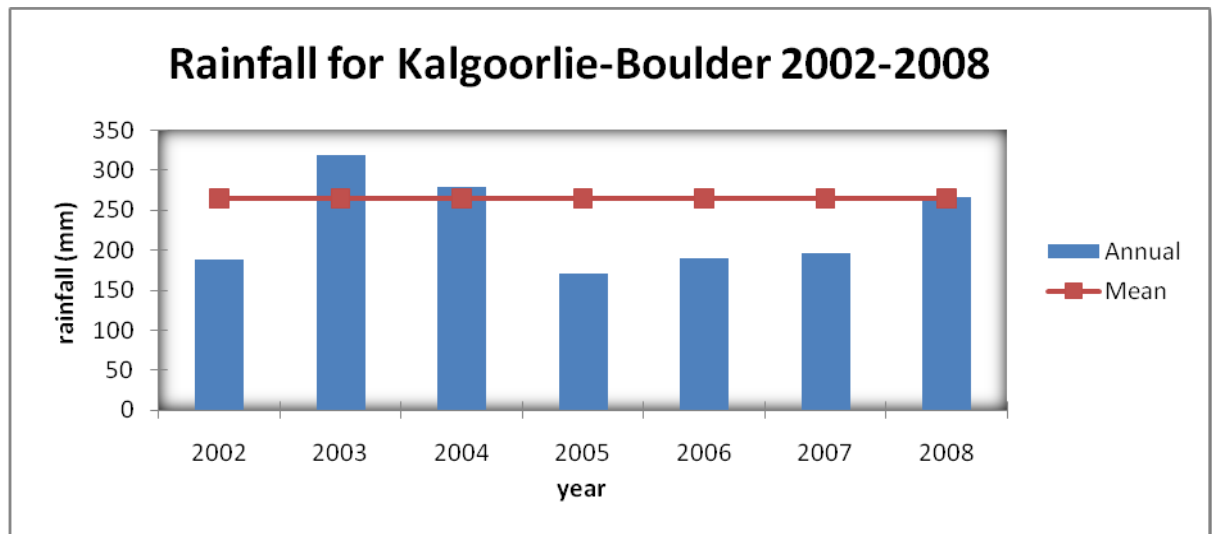


Figure 6: Average annual rainfall data for Kalgoorlie-Boulder from 2000 to 2008 Bureau of Meteorology (BOM, 2009).

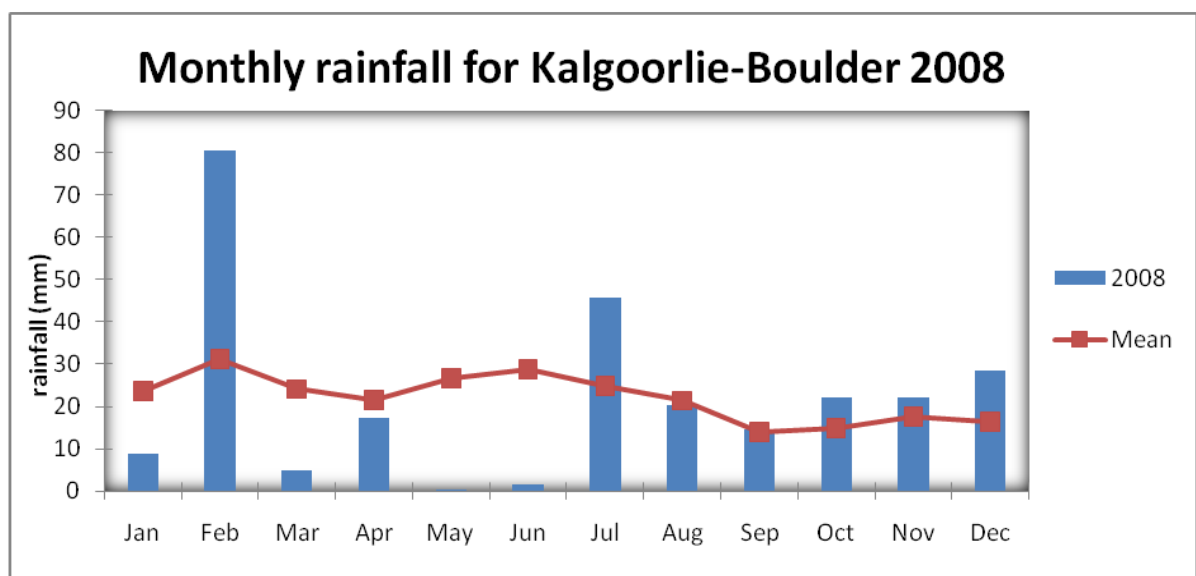


Figure 7: Monthly rainfall data for Kalgoorlie-Boulder from January 2008 to December 2008 Bureau of Meteorology (BOM, 2009).

3 Photographic Monitoring

3.1 OTD area



Figure 8: OTD Area Transect 1 View from Bottom 2007.



Figure 9: OTD Area Transect 1 View from Bottom 2009.



Figure 10: OTD Area Transect 2 View from Bottom 2007.



Figure 11: OTD Area Transect 2 View from Bottom 2009.

3.2 Pad 19



Figure 12: Pad 19 Transect 1 View from Bottom 2007.

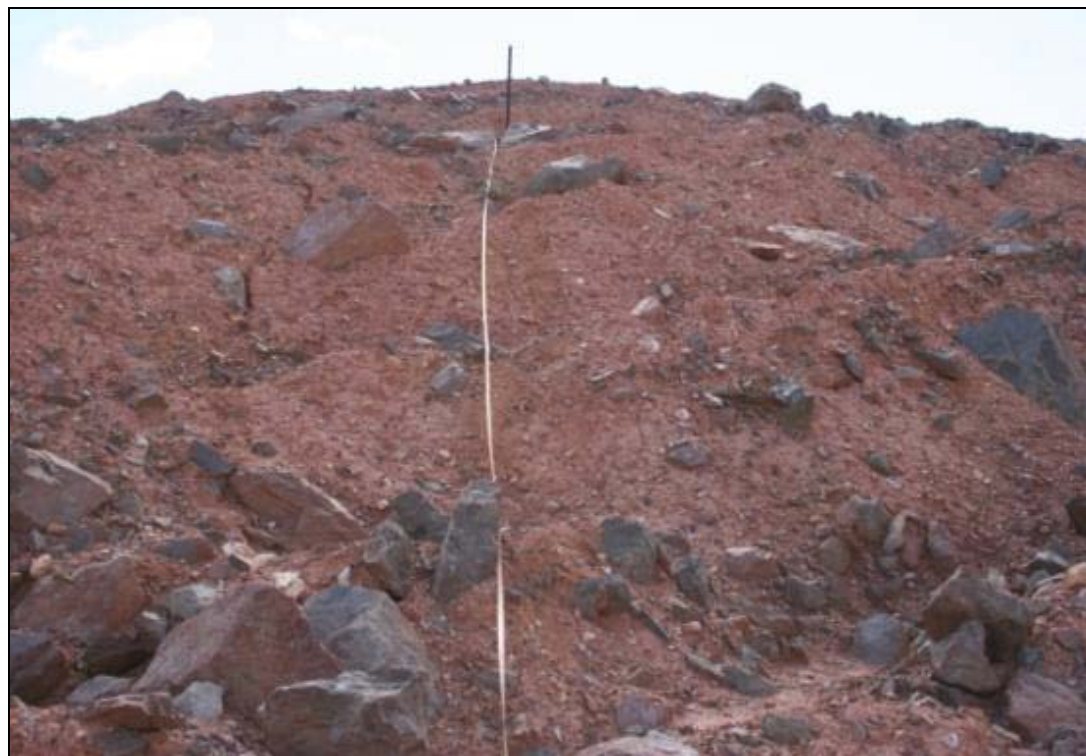


Figure 13: Pad 19 Transect 1 View from Bottom 2009.



Figure 14: Pad 19 Transect 2 View from Bottom 2007.



Figure 15: Pad 19 Transect 2 View from Bottom 2009.



Figure 16: Pad 19 Transect 3 View from Bottom 2007.



Figure 17: Pad 19 Transect 3 View from Bottom 2009.

3.3 Radio Hill



Figure 18: Radio Hill Transect 1 View from Bottom 2007



Figure 19: Radio Hill Transect 1 View from Bottom 2009



Figure 20: Radio Hill Transect 2 View from Top 2007



Figure 21: Radio Hill Transect 2 View from Top 2009



Figure 22: Radio Hill Transect 3 View from Bottom 2007.



Figure 23: Radio Hill Transect 3 View from Bottom 2009.



Figure 24: Break in Berm on Second Lift (Near Radio Hill Transect 3)



Figure 25: Tunnelling down slope from break in berm near Transect 3

4 Results

4.1 Pad 19: Transect 1

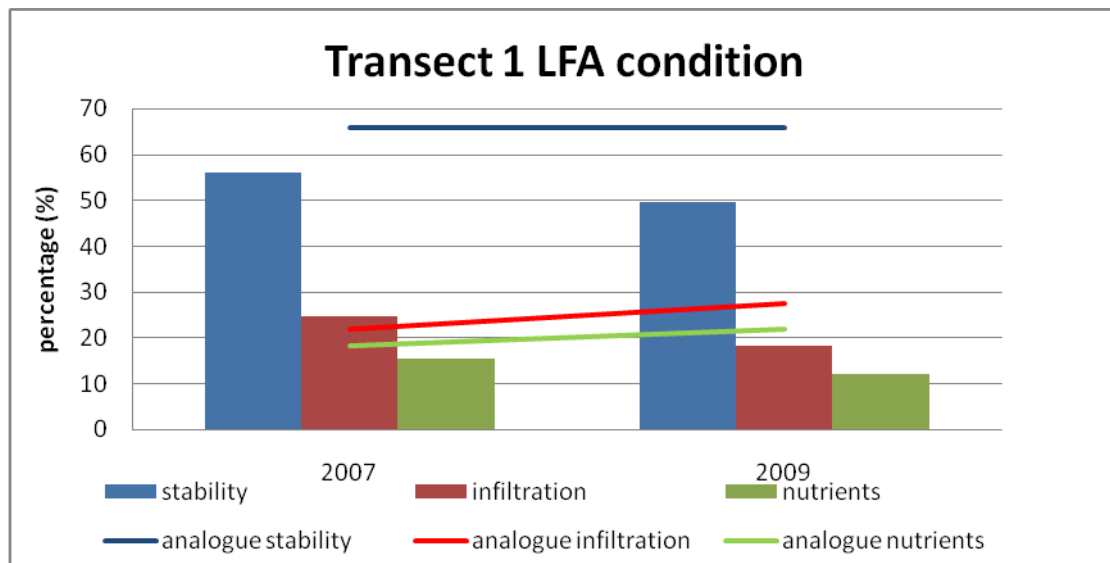


Figure 26: LFA Data Pad 19 Transect 1

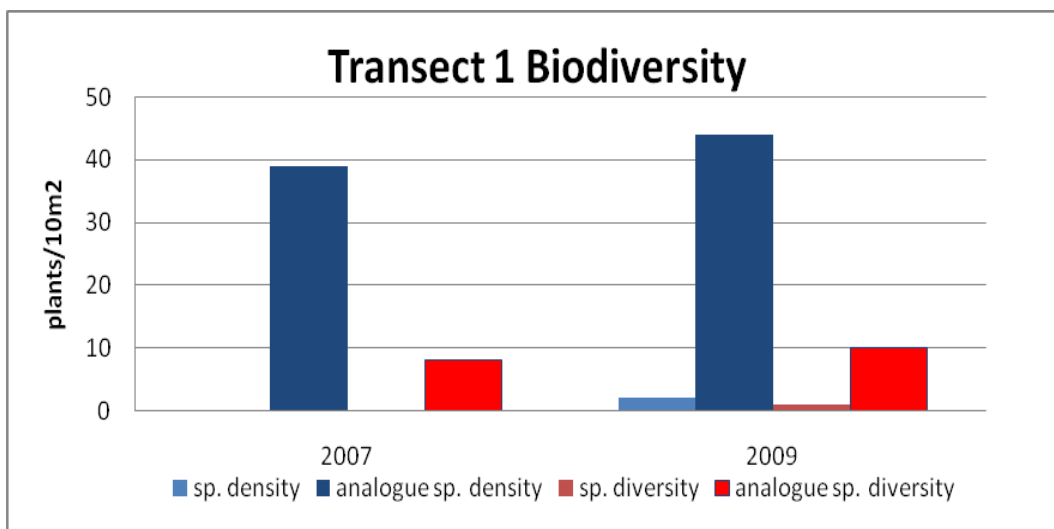


Figure 27: Biodiversity Data Pad 19 Transect 1. (No vegetation present in T1 2007)

4.2 Pad 19 Transect 2

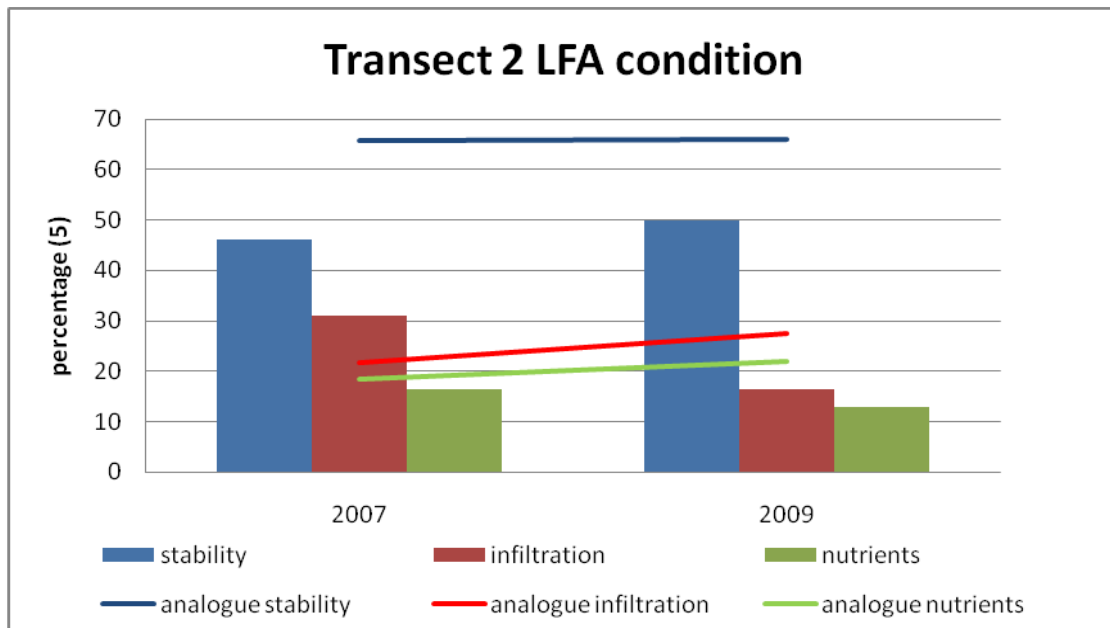


Figure 28: LFA Data Pad 19 Transect 2

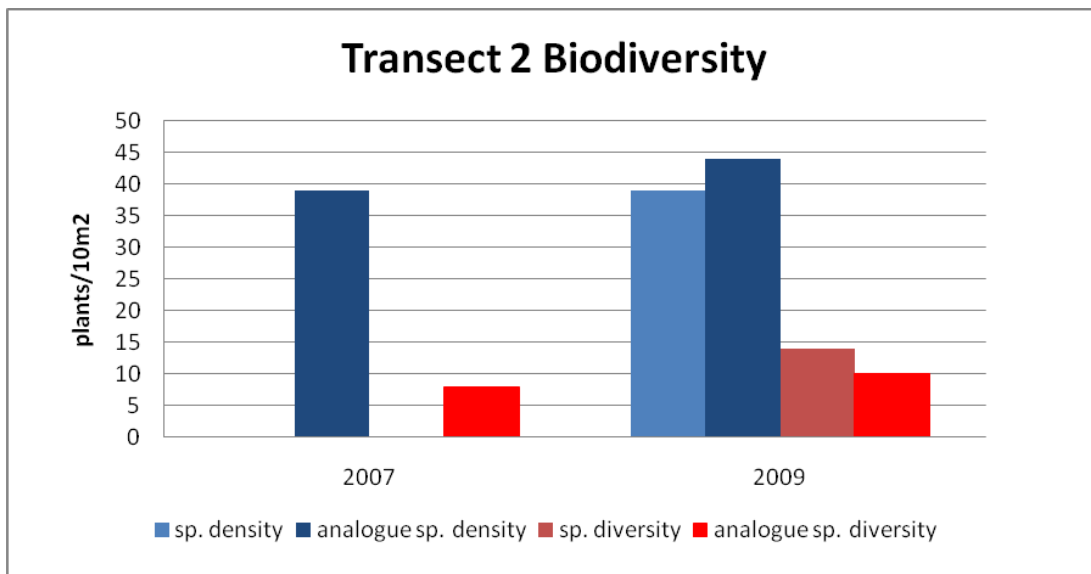


Figure 29: Biodiversity Data Pad 19 Transect 2. (No vegetation present in T2 2007).

4.3 Pad 19 Transect 3

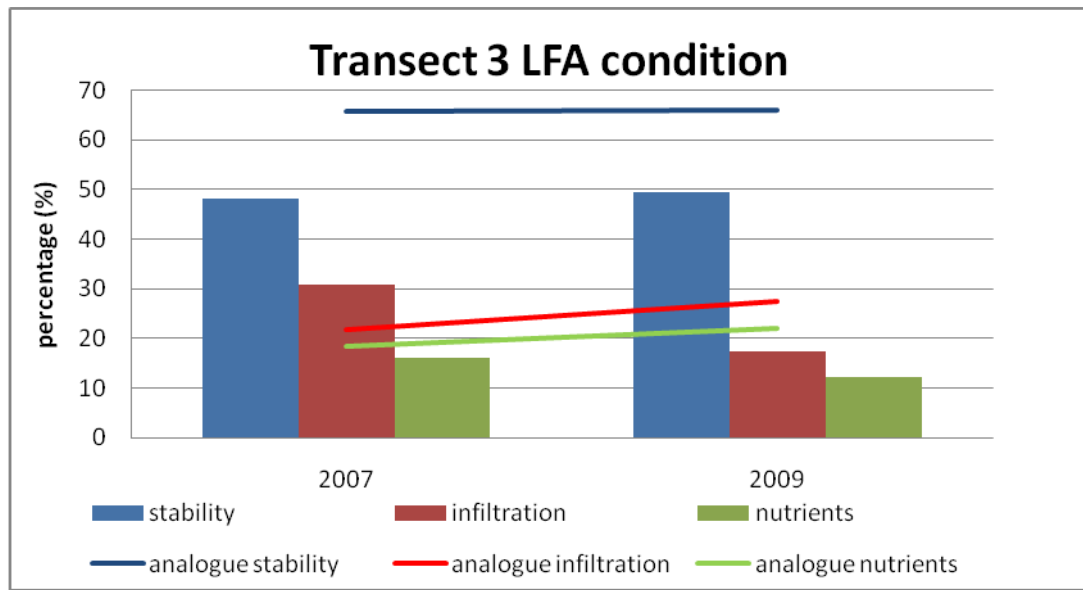


Figure 30: LFA Data Pad 19 Transect 3

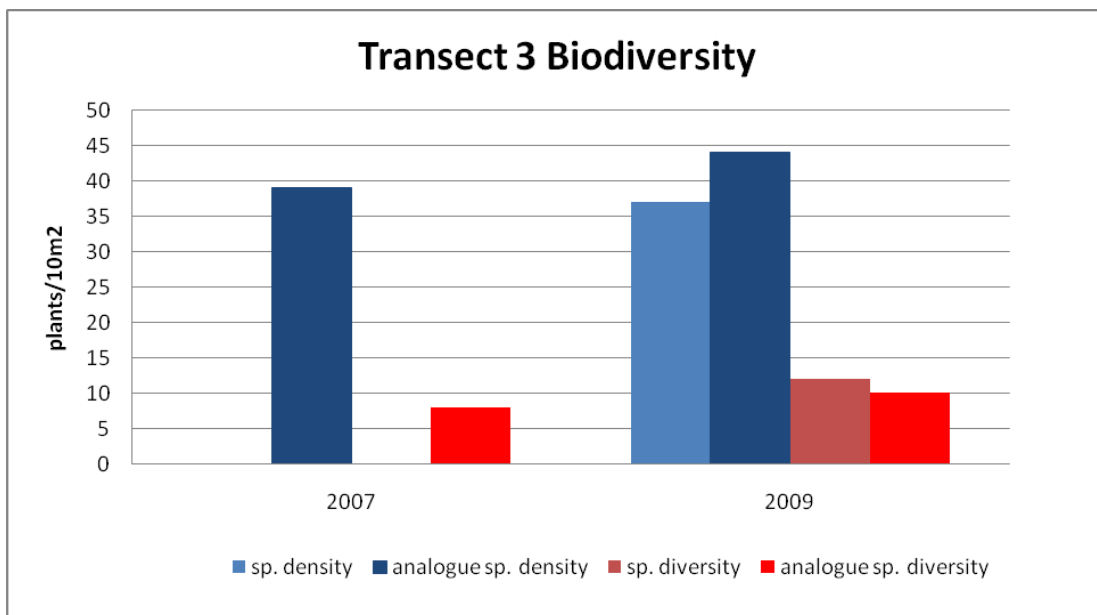


Figure 31: Biodiversity Data Pad 19 Transect 3. (No vegetation present in T3 2007).

4.4 OTD Transect 1

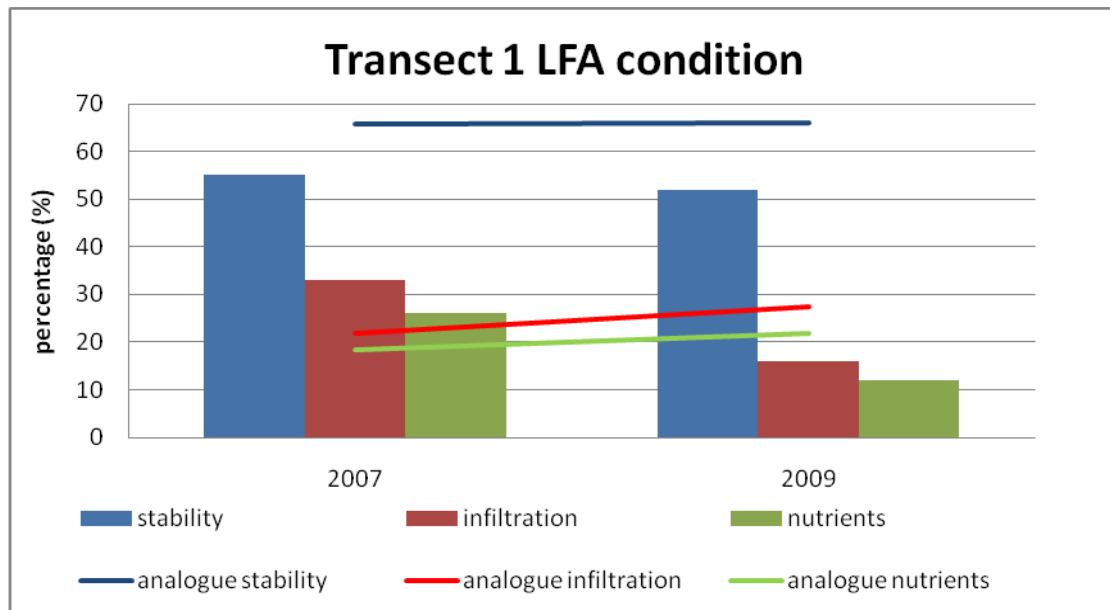


Figure 32: LFA Data OTD Transect 1

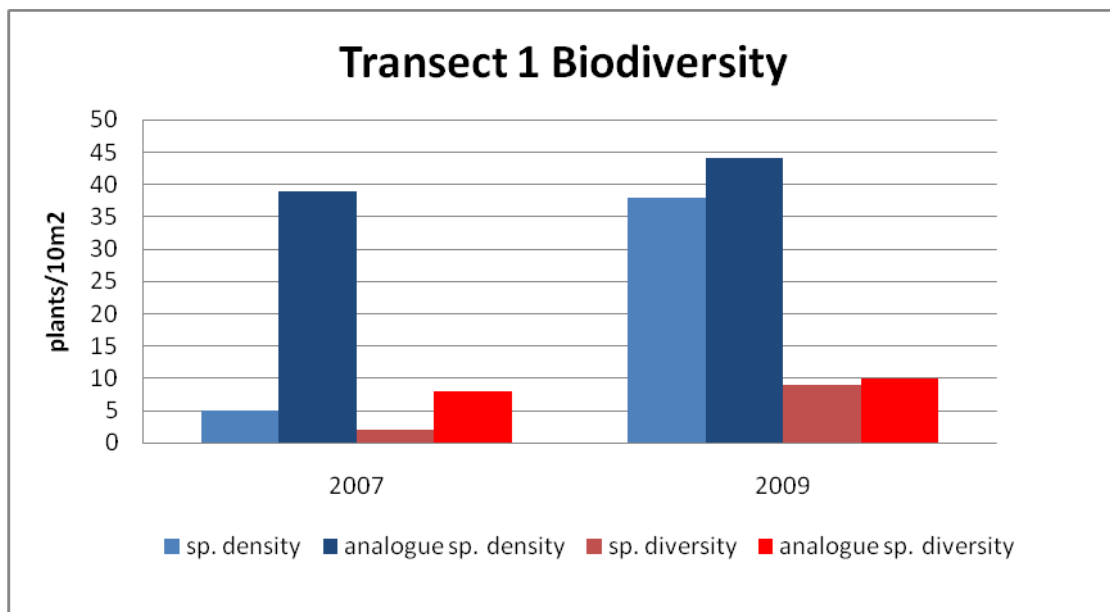


Figure 33: Biodiversity Data OTD Transect 1

4.5 OTD Transect 2

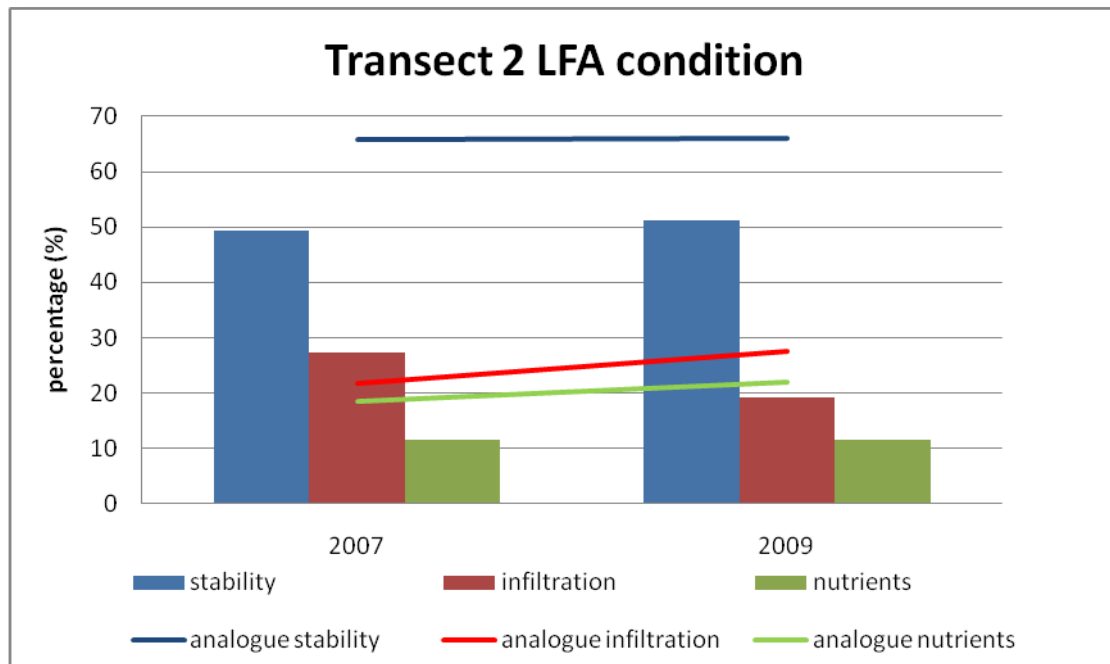


Figure 34: LFA Data OTD Transect 2

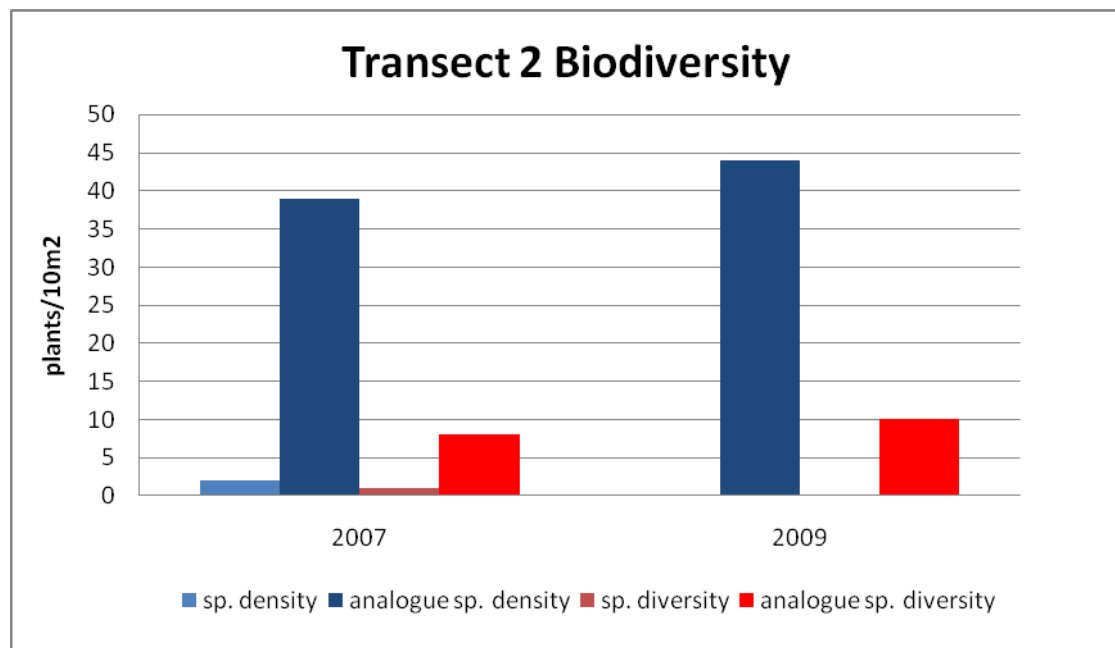


Figure 35: Biodiversity Data OTD Transect 2

4.6 Radio Hill Transect 1

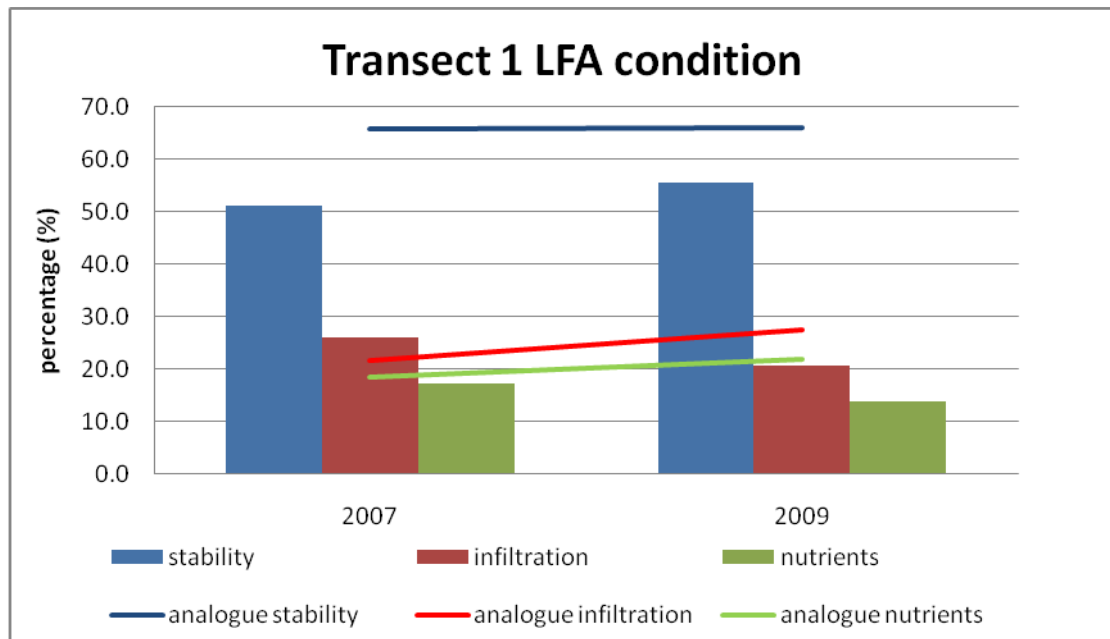


Figure 36: LFA Data Radio Hill Transect 1

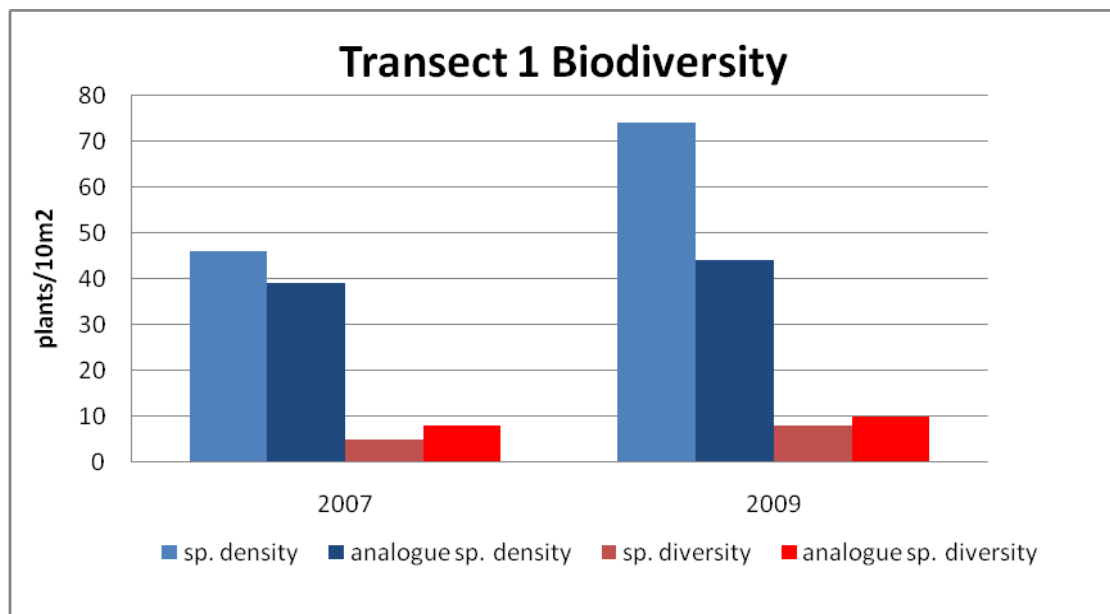


Figure 37: Biodiversity Data Radio Hill Transect 1

4.7 Radio Hill Transect 2

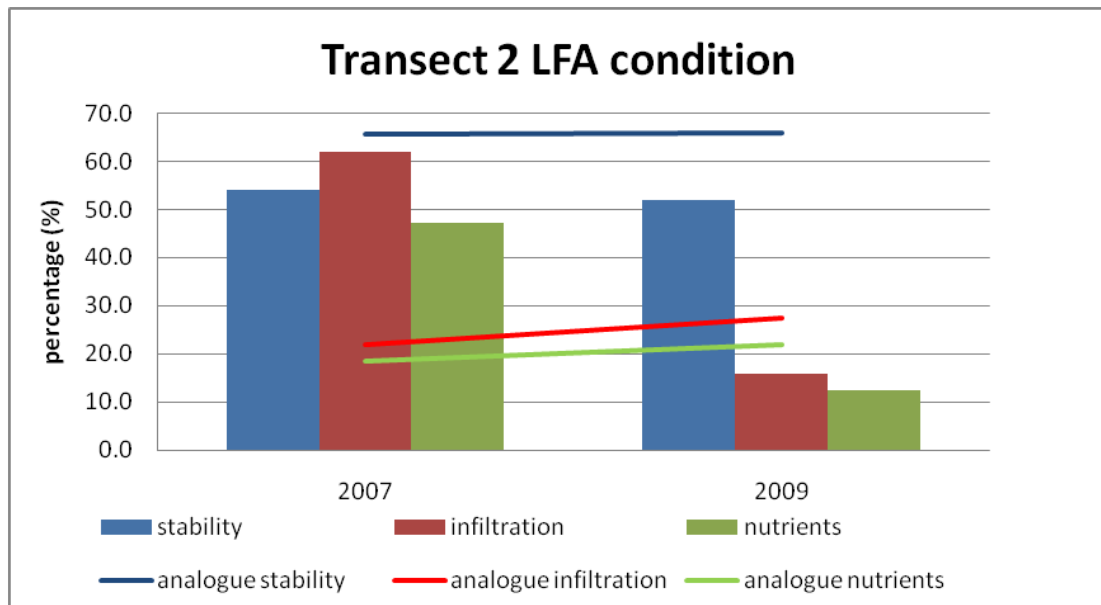


Figure 38: LFA Data Radio Hill Transect 2

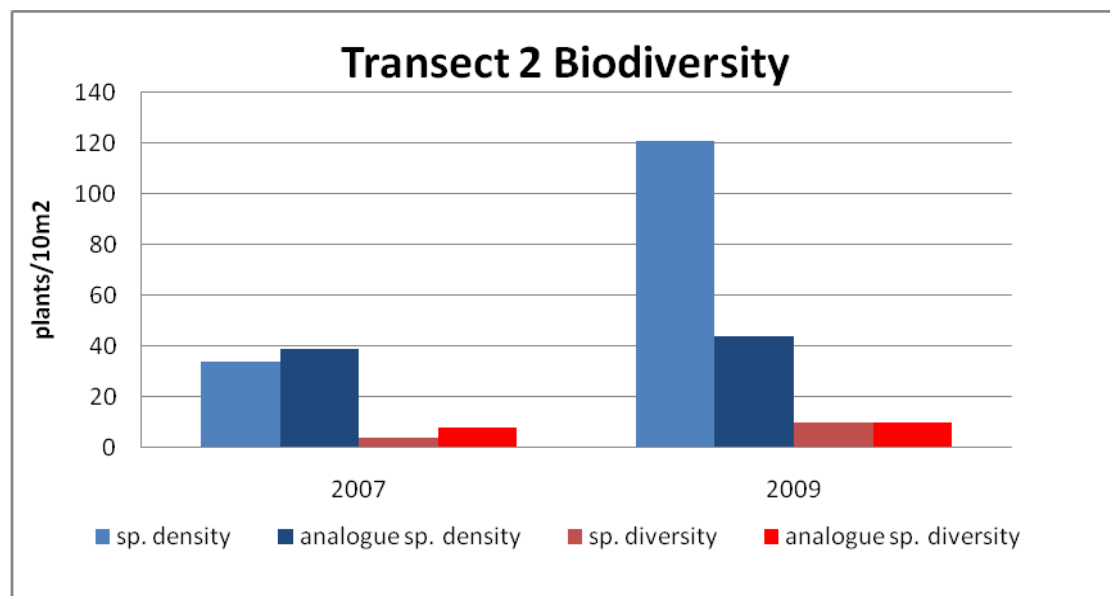


Figure 39: Biodiversity Data Radio Hill Transect 2

4.8 Radio Hill Transect 3

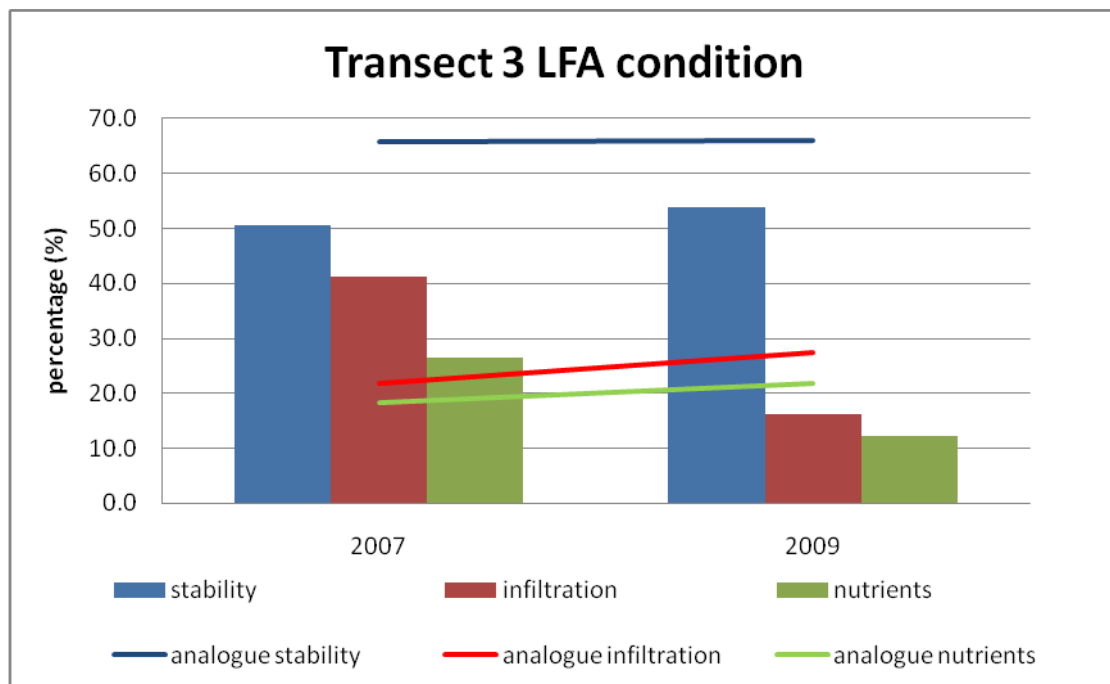


Figure 40: LFA Data Radio Hill Transect 3

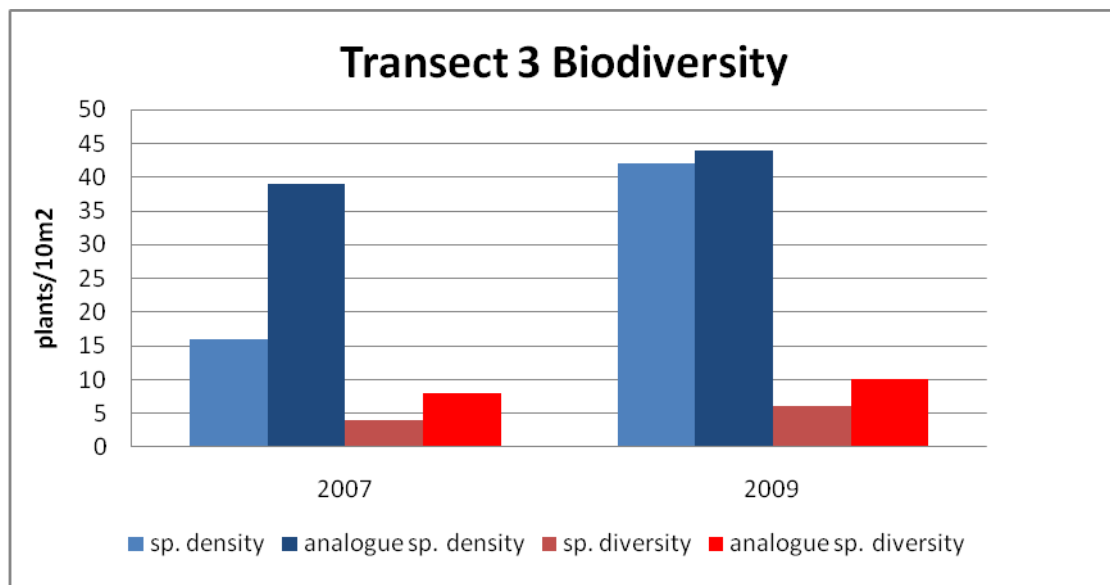


Figure 41: Biodiversity Data Radio Hill Transect 3

5 Discussion Pad 19

Pad 19 was seeded with a secondary oxide seed mix in 2008. Transect 1 is located on the south-west corner of the Pad 19 waste rock landform and has high blue rock cover. All three LFA indices decreased and there has been little to no vegetation growth since 2007 with only one species present in 2009. This lack of vegetation growth may be due to the additional rehabilitation work conducted in the area to correct the positioning of rip lines after they were initially developed down the slope rather than across the slope face. Leaf litter cover was low and ants were seen within the area.

Transect 2, located on the south-westerly aspect had an increase in stability from 2007 however nutrient cycling and infiltration levels both decreased. 2009 was the first year of monitoring that vegetation was present and species density was quite high, recording a similar level to the analogue site. Species diversity was also high, exceeding diversity levels of the analogue site. Leaf litter cover was low and ants were seen within the area.

The soils of Transect 3 (closest transect to the road tunnel, south-westerly aspect) appeared to contain more oxide than the other two transects. In 2009 stability increased however both infiltration and nutrient cycling decreased. Species density was good and species diversity was very high, recording a greater number of species than the analogue site. Leaf litter cover was low and ants were seen within the area.

Infiltration and nutrient cycling levels both decreased despite increasing levels of plant density, diversity, stability and above average rainfall; with 65.4mm received in January 2009 (the average for January is 23.6mm). Many new germinants of *Eucalyptus* and *Acacia* species were seen on the waste landform. Although plant density has increased vegetation cover and leaf litter production has remained relatively low with many plants in early life stages (i.e. germinants, juveniles). Vegetation cover and plant litter are important in preventing resources being transported by wind and water too rapidly across the surface, resulting in decreased water infiltration and increased soil erosion (Tongway & Hindley, 2003). There is some evidence of ecosystem improvement with ants located within all three transects. No weed species were identified within the transects.

6 Discussion OTD

Transect 1 is located on the western face overlooking the Fimiston open pit. The area has high exposure to wind. All three LFA indices decreased in 2009 however both species density and diversity increased. There was evidence of riling and tunnelling within the transect.

Transect 2, located approximately 200m east of transect 1 occurs on very poor soils, containing high levels of oxide and consisting of a soft yellow-grey material. Despite the poor soil condition and evidence of tunnelling within the transect, stability increased in 2009. Infiltration and nutrient cycling both decreased as did species density and diversity with no vegetation growing in 2009.

As mentioned previously, infiltration and nutrient cycling levels decreased as vegetation cover and plant litter remained low, preventing resources from being retained in the system (Tongway & Hindley, 2003). Both transects have been subject to erosion with transect 1 in a highly exposed area and transect 2 having poor, soft soils.

7 Discussion Radio Hill

Transect 1 is located on the southern face of the Radio Hill waste rock landform. Stability levels increased in 2009 despite evidence of minor riling and erosion within the transect. Infiltration and nutrient cycling both decreased. Transect 1 has recorded high levels of density in both 2007 and 2009 with levels exceeding that of the analogue site. Despite the decrease in LFA condition, in 2009 species density reached significantly high levels, greater than that of the analogue site.

Transect 2, located on the southern aspect had an increase in stability from 2007 however nutrient cycling and infiltration levels both decreased significantly. This substantial decrease from 2007 appears to be due to a decrease in leaf litter accumulation within the system. Despite the significant drop in nutrient cycling and infiltration, species density increased and currently exceeds density levels of the analogue site. Species diversity also increased to a level equal to the analogue site.

Transect 3, located on the western aspect had an increase in stability from 2007 despite major signs of erosion (Figure 38 & 39). There is a break in the berm on the second lift causing tunnelling down the slope which has resulted in a break in the berm of the first lift (right of the transect). This is leading to a high level of run off with water flowing with greater force onto the road below. Remedial work will need to be conducted to fix the berms to prevent further erosion and loss of top soil. Infiltration and nutrient cycling levels both decreased which may be due to the high run off caused by the broken berms. Despite the decrease in nutrient cycling and infiltration species density and diversity levels increased yet did not exceed levels of the analogue site.

The break in the berm above transect 3 has caused a high level of run off in the area resulting in decreasing levels of infiltration and nutrient cycling. Despite the high level of erosion occurring near the transect, the transect itself recorded increased stability. This may be due to the increase in species density from 2007 to 2009, which increases soil stability. Once again low vegetation cover and leaf litter production also explains the decreasing levels of infiltration and nutrient cycling within the transect.

8 Conclusion

Although infiltration and nutrient cycling levels of all the transects within the Pad 19 area decreased in 2009, the condition of Transects 2 and 3 appears to be improving. Both transects recorded an increase in stability and the banks and troughs remain intact. They also both contain a good level of plant density and high species diversity, even having greater species diversity level than the analogue site. Whether this level of vegetation growth and subsequent LFA improvement continues will be determined following further monitoring. Transect 1 is still in very early stages of rehabilitation having had additional work done to correct faulty rip lines. It will take several years longer than the other two transects to show improvement in LFA condition.

Both transects within the OTD area recorded a decrease in infiltration and nutrient cycling levels with transect 1 also having a decreased level of stability. Biodiversity of transect 1 was good with high plant density and species diversity despite the worsening conditions. Transect 2 is located on poor soils and the minimal amount of vegetation initially growing in the area has died off. Future monitoring will determine whether the soils of transect 2 are capable of supporting plant life.

All three of the Radio Hill transects had increased levels of stability yet both infiltration and nutrient cycling decreased. Vegetation within the transects however

has improved with increasing species density and species diversity levels. Species density of transects 1 and 2 even exceeded density levels of the analogue site.

The area near transect 3 has been subject to high levels of erosion, with several berms in the area becoming breached causing significant tunnelling and water run off. As this problem has been identified early in monitoring and provided remedial work is carried out soon, this erosion should not prevent successful rehabilitation of the area in the future.

LFA is a process, which requires a timeline to assess the health of a landscape and also requires the comparison of results from both the target rehabilitated sites and a similar geographical analogue site. With continual monitoring via LFA, action can be taken to improve one or more of the three system indices (stability, infiltration and nutrient cycling), and help generate a self-sustaining system from the early stages of rehabilitation.

9 Recommendations

- Rehabilitation monitoring to be continued at annual intervals.
- At present no weed species are found within any transects yet weeds still need to be monitored each year. Early control of weeds will limit their spread and stop infestation on the rehabilitation.
- Area at Pad19 where ripping on the contour was carried out after seeding this area to be re seeded if no vegetation is recorded in the near future.
- Damage to the berm on the first and second lift of the Radio Hill western slope (near transect 3) needs to be repaired quickly to prevent further water run off.
- Secondary seeding of OTD and Radio Hill to be carried out with the KCGM oxide secondary seed mix.

10 References

Beard, J.S. (1990), *Plant Life of Western Australia*, Kangaroo Press Pty Ltd, NSW.

Bureau of Meteorology (2009). *Average Annual Rainfall for Kalgoorlie-Boulder from 2000-2008 and 2008 Monthly Rainfall*.

http://www.bom.gov.au/jsp/ncc/cdio/weatherData/av?p_nccObsCode=139&p_display_type=dataFile&p_stn_num=012038

Accessed: 26/5/09

Ludwig et al, (1997) *Landscape Ecology Function and Management*, CSIRO

Tongway, D and Hindley, N (July 2003), *Indicators of Ecosystem Rehabilitation Success, Stage 2 – Verification of EFA Indicators (Final Report)*, Prepared for the Australian Centre for Environmental Research.

Tongway, D and Hindley, N (2004), *Landscape Function Analysis: Procedures for Monitoring and Assessing Landscapes (with special reference to mine sites and rangelands)*, CSIRO.

WAHERB, (2009), *Florabase – Information on the Western Australian Flora*. Department of Environment and Conservation.

<http://florabase.dec.wa.gov.au>

Accessed 27/05/09

Appendix 1: LFA data 2007-2009

Pad 19

Transect	Stab. 07	Stab. 09	Infil. 07	Infil. 09	NC 07	NC 09
1	56.2	49.6	24.6	18.2	15.6	12.2
2	46.0	50.0	30.9	16.4	16.3	12.9
3	48.1	49.4	30.7	17.4	16.1	12.1
mean	50.1	49.7	28.7	17.3	16.0	12.4

OTD

Transect	Stab. 07	Stab. 09	Infil. 07	Infil. 09	NC 07	NC 09
1	55.2	52	32.9	15.9	26	11.9
2	49.4	51.3	27.4	19.3	11.6	11.6
mean	52.3	51.65	30.15	17.6	18.8	11.75

Radio Hill

Transect	Stab. 07	Stab. 09	Infil. 07	Infil. 09	NC 07	NC 09
1	51.2	55.6	26.1	20.7	17.4	13.8
2	54.2	51.9	61.9	16.0	47.1	12.4
3	50.5	53.8	41.2	16.3	26.5	12.2
mean	52.0	53.8	43.1	17.7	30.3	12.8

Appendix 2: Biodiversity data 2007-2009

Pad 19**Transect 1**

Family	Genus	Species	2007	2009
Zygophyllaceae	<i>Zygophyllum</i>	<i>eremaeum</i>		2
Sp. density			0	2
Sp. diversity			0	1

Transect 2

Family	Genus	Species	2007	2009
Amaranthaceae	<i>Ptilotus</i>	<i>exaltatus</i>		3
Amaranthaceae	<i>Ptilotus</i>	<i>obovatus</i>		1
Chenopodiaceae	<i>Atriplex</i>	<i>bunburyana</i>		3
Chenopodiaceae	<i>Atriplex</i>	<i>codonocarpa</i>		2
Chenopodiaceae	<i>Atriplex</i>	<i>lindleyi</i>		1
Chenopodiaceae	<i>Atriplex</i>	<i>nummularia</i>		5
Chenopodiaceae	<i>Atriplex</i>	<i>semibaccata</i>		1
Chenopodiaceae	<i>Maireana</i>	<i>pyramidata</i>		3
Chenopodiaceae	<i>Maireana</i>	<i>tomentosa</i>		6
Chenopodiaceae	<i>Salsola</i>	<i>tragus</i>		1
Chenopodiaceae	<i>Sclerolaena</i>	<i>diacantha</i>		1
Myrtaceae	<i>Eucalyptus</i>	<i>sp.</i>		1
Poaceae	<i>Grass</i>	<i>sp.</i>		1
Zygophyllaceae	<i>Zygophyllum</i>	<i>eremaeum</i>		10
Sp. density			0	39
Sp. diversity			0	14

Transect 3

Family	Genus	Species	2007	2009
Chenopodiaceae	<i>Atriplex</i>	<i>bunburyana</i>		5
Chenopodiaceae	<i>Atriplex</i>	<i>nummularia</i>		6
Chenopodiaceae	<i>Atriplex</i>	<i>semibaccata</i>		1
Chenopodiaceae	<i>Atriplex</i>	<i>semilunaris</i>		2
Chenopodiaceae	<i>Atriplex</i>	<i>vesicaria</i>		1
Chenopodiaceae	<i>Maireana</i>	<i>brevifolia</i>		1
Chenopodiaceae	<i>Maireana</i>	<i>pentatropis</i>		1
Chenopodiaceae	<i>Maireana</i>	<i>tomentosa</i>		4
Chenopodiaceae	<i>Maireana</i>	<i>triptera</i>		5
Chenopodiaceae	<i>Sclerolaena</i>	<i>diacantha</i>		2
Mimosaceae	<i>Acacia</i>	<i>hemiteles</i>		1
Myrtaceae	<i>Eucalyptus</i>	<i>sp.</i>		5
Zygophyllaceae	<i>Zygophyllum</i>	<i>eremaeum</i>		3
Sp. density			0	37
Sp. diversity			0	12

OTD**TRANSECT 1**

Family	Genus	Species	2007	2009
Amaranthaceae	<i>Ptilotus</i>	<i>exaltatus</i>		5
Chenopodiaceae	<i>Maireana</i>	<i>pentatropis</i>		2
Chenopodiaceae	<i>Maireana</i>	<i>pyramidata</i>	2	
Chenopodiaceae	<i>Maireana</i>	<i>triptera</i>	3	17
Chenopodiaceae	<i>Salsola</i>	<i>tragus</i>		1
Chenopodiaceae	<i>Sclerolaena</i>	<i>diacantha</i>		7
Mimosaceae	<i>Acacia</i>	<i>acuminata</i>		1
Mimosaceae	<i>Acacia</i>	<i>victoriae</i>		3
Myrtaceae	<i>Eucalyptus</i>	<i>sp.</i>		1
Zygophyllaceae	<i>Zygophyllum</i>	<i>eremaeum</i>		1
Sp. density			5	38
Sp. diversity			2	9

TRANSECT 2

Family	Genus	Species	2007	2009
Chenopodiaceae	<i>Maireana</i>	<i>triptera</i>	2	
Sp. density			2	0
Sp. diversity			1	0

Radio Hill**Transect 1**

Family	Genus	Species	2007	2009
Chenopodiaceae	<i>Atriplex</i>	<i>codonocarpa</i>	8	
Chenopodiaceae	<i>Atriplex</i>	<i>lindleyi</i>	2	9
Chenopodiaceae	<i>Atriplex</i>	<i>nummularia</i>		1
Chenopodiaceae	<i>Atriplex</i>	<i>vesicaria</i>		13
Chenopodiaceae	<i>Maireana</i>	<i>georgei</i>		2
Chenopodiaceae	<i>Maireana</i>	<i>pyramidata</i>	9	5
Chenopodiaceae	<i>Maireana</i>	<i>tomentosa</i>		18
Chenopodiaceae	<i>Maireana</i>	<i>triptera</i>	8	1
Chenopodiaceae	<i>Salsola</i>	<i>tragus</i>	19	20
Zygophyllaceae	<i>Zygophyllum</i>	<i>eremaeum</i>		5
Sp. Density			46	74
Sp. Diversity			5	8

Transect 2

Family	Genus	Species	2007	2009
Chenopodiaceae	<i>Atriplex</i>	<i>bunburyana</i>	5	3
Chenopodiaceae	<i>Atriplex</i>	<i>codonocarpa</i>		2
Chenopodiaceae	<i>Atriplex</i>	<i>lindleyi</i>		40
Chenopodiaceae	<i>Atriplex</i>	<i>nummularia</i>		1
Chenopodiaceae	<i>Atriplex</i>	<i>vesicaria</i>		1
Chenopodiaceae	<i>Maireana</i>	<i>brevifolia</i>		4
Chenopodiaceae	<i>Maireana</i>	<i>pyramidata</i>	12	10
Chenopodiaceae	<i>Maireana</i>	<i>tomentosa</i>		30
Chenopodiaceae	<i>Maireana</i>	<i>triptera</i>	10	
Chenopodiaceae	<i>Salsola</i>	<i>tragus</i>	7	17
Chenopodiaceae	<i>Sclerolaena</i>	<i>diacantha</i>		10
Zygophyllaceae	<i>Zygophyllum</i>	<i>eremaeum</i>		3
Sp. Density			34	121
Sp. Diversity			4	10

Transect 3

Family	Genus	Species	2007	2009
Amaranthaceae	<i>Ptilotus</i>	<i>obovatus</i>		8
Chenopodiaceae	<i>Atriplex</i>	<i>bunburyana</i>	4	
Chenopodiaceae	<i>Atriplex</i>	<i>codonocarpa</i>		13
Chenopodiaceae	<i>Atriplex</i>	<i>lindleyi</i>	1	2
Chenopodiaceae	<i>Maireana</i>	<i>pyramidata</i>	3	
Chenopodiaceae	<i>Maireana</i>	<i>tomentosa</i>		12
Chenopodiaceae	<i>Maireana</i>	<i>triptera</i>	8	5
Zygophyllaceae	<i>Zygophyllum</i>	<i>eremaeum</i>		2
Sp. Density			16	42
Sp. Diversity			4	6

Appendix 3: EFA summary of Pad 19 2009

Revegetation/EFA specifications: (NB: T=Transect)

Landform	Pad 19
Location	1.6km E of the Eastern Bypass Road.
Date of Earthworks / Rehabilitation	Ripped in 2006. Transect 1 was ripped once again in 2007 to fix faulty rip lines
Earthworks Contractor	Jims Seeds & Ozcon
Ripping Depth	
Growth Medium Used	oxide
Growth Medium Depth	
Pioneer Seed Mix	Seeded in Jan 2007
Secondary Seed Mix	Seeded in Jan 2008
Seed Application	Hand seeded
Soil Treatments (eg gypsum, mulch)	none
EFA Monitoring Schedule	January
EFA Assessor	NG (2007) AW & LP (2009)
GPS Coordinates of Transects (GDA 94 51 J)	T1- 51 J 0357563E 6595691N T2- 51 J 0357483E 6595801N T3- 51 J 0357248E 6595911N
Aspect	South-west aspects
Slope Angle	All transects 15°.

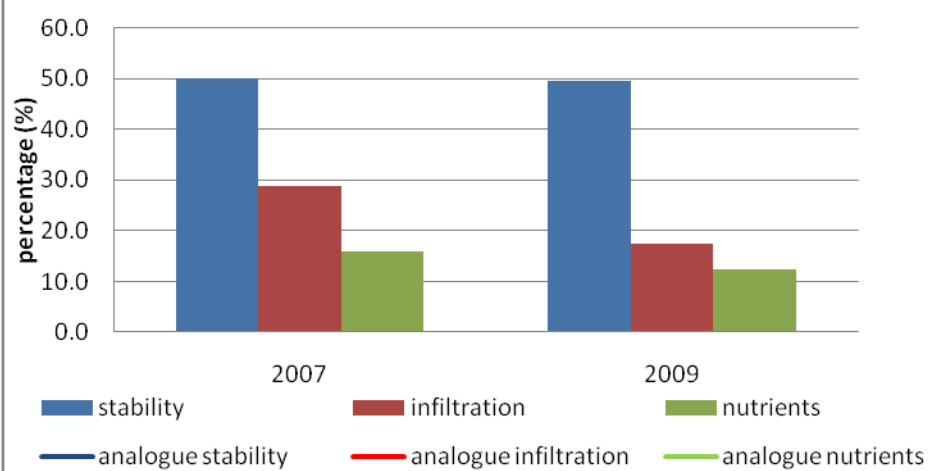
Location of site:



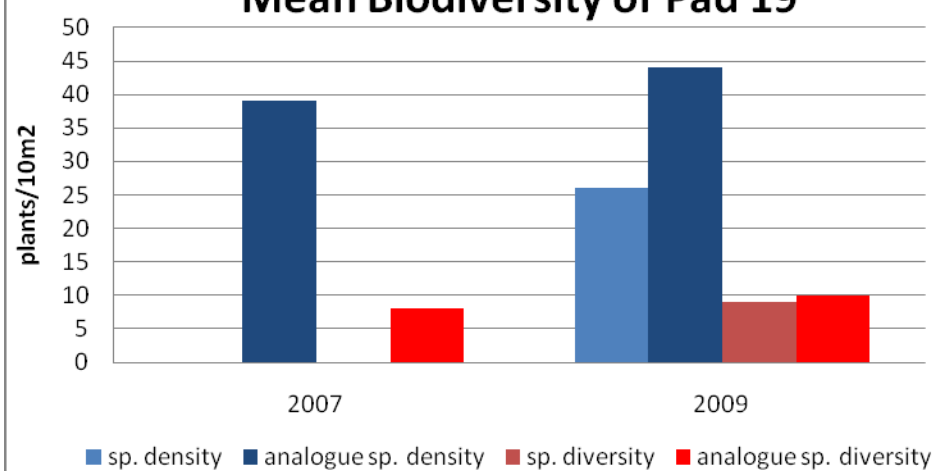
Rehabilitation trends:

Criteria	2007 mean	2009 mean	2007 comparison to 2009	Comments
Stability (%)	50.1	49.7	Decreased	Banks and troughs intact no erosion evident
Infiltration (%)	28.7	17.3	Decreased	Juvenile Low vegetation cover and leaf litter accumulation preventing resource retention
Nutrient Cycling (%)	16	12.4	Decreased	Low vegetation cover and leaf litter accumulation preventing resource retention.
Species Density (plants/10m ²)	0	26	Increased	High species density except transect 1
Species Diversity (plants/10m ²)	0	9	Increased	<i>Chenopodiaceae</i> family most dominant. Some <i>Acacias</i> and <i>Eucalyptus</i> present
Weed Density (plants/10m ²)	0	0	Same	No weed species found from 2007-2009
Growth Medium pH	N/A	8.2	N/A	Low acidity
Growth Medium Ec (mS/m)	N/A	302.7	N/A	High soil salinity

Mean LFA condition of Pad 19



Mean Biodiversity of Pad 19



NB: No vegetation growing in 2007

Appendix 4: EFA summary of OTD 2009

Revegetation/EFA Specifications: (NB: T=Transect)

Landform	OTD
Location	1.8km E of the Eastern Bypass Road.
Date of Earthworks / Rehabilitation	2006
Earthworks Contractor	Ozcon/Jim Seeds
Ripping Depth	
Growth Medium Used	oxide
Growth Medium Depth	
Pioneer Seed Mix	Oxide pioneer seed mix 18 ha seeded April 2007
Secondary Seed Mix	
Seed Application	Hand seeded
Soil Treatments (eg gypsum, mulch)	none
EFA Monitoring Schedule	January
EFA Assessor	NG (2007) AW & LP (2009)
GPS Coordinates of Transects (GDA 94 51 J)	T1- 51 J 0357926E 6593666N T2- 51 J 0358110E 6593720N
Aspect	Western aspects
Slope Angle	All transects 15°.

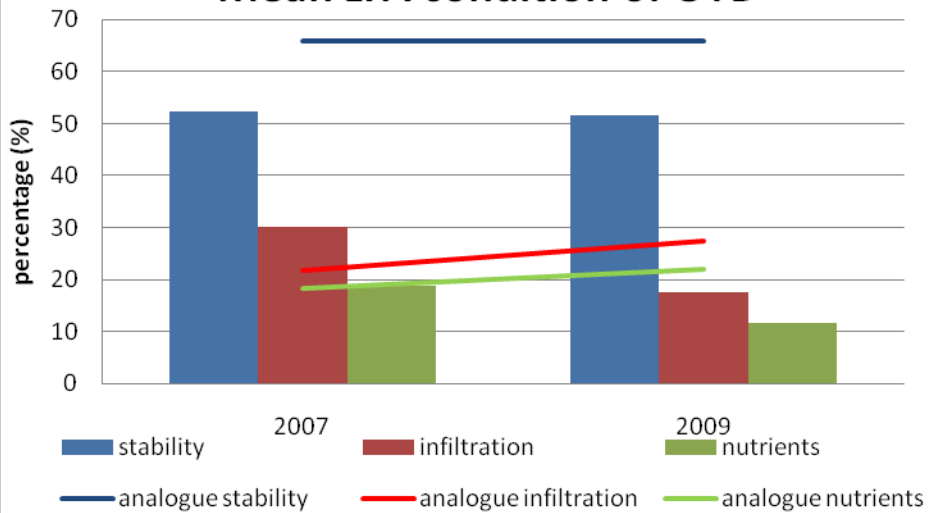
Location of site:



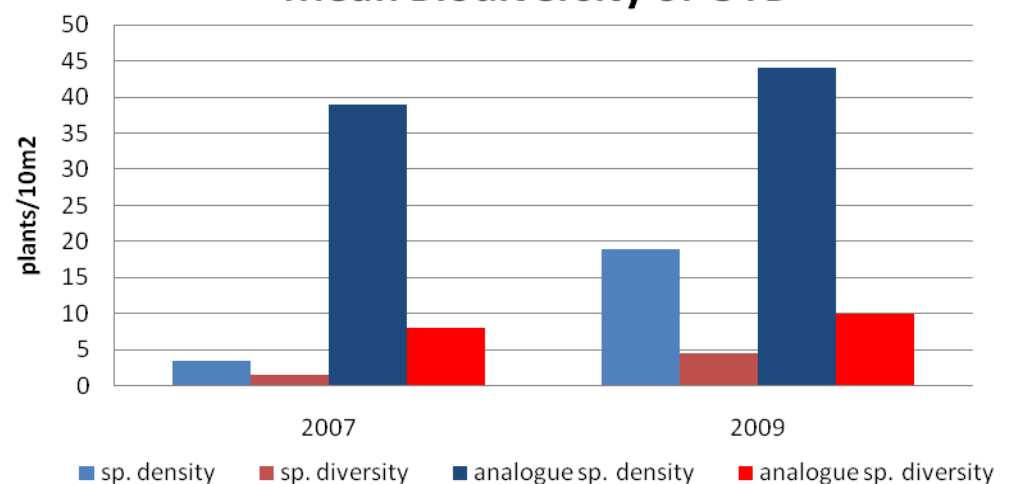
Rehabilitation trends:

Criteria	2007 mean	2009 mean	2007 comparison to 2009	Comments
Stability (%)	52.3	51.6	Decreased	Poor soils at T2, high exposure in T1. Erosion at both transects
Infiltration (%)	30.1	17.6	Decreased	Decrease despite high rainfall for Jan 09. Low vegetation cover and leaf litter accumulation preventing resource retention
Nutrient Cycling (%)	18.8	11.7	Decreased	Low vegetation cover and leaf litter accumulation preventing resource retention. Poor soils at T2
Species Density (plants/10m ²)	3.5	19	Increased	No vegetation at Transect 2. Died off from 2007
Species Diversity (plants/10m ²)	1.5	4.5	Increased	<i>Chenopodiaceae</i> family most dominant.
Weed Density (plants/10m ²)	0	0	Same	No weed species found from 2007-2009
Growth Medium pH	N/A	8.2	N/A	Low acidity
Growth Medium Ec (mS/m)	N/A	351.8	N/A	High soil salinity

Mean LFA condition of OTD



Mean Biodiversity of OTD



Revegetation/EFA Specifications: (NB: T=Transect)

Landform	Radio Hill
Location	1.8km E of the Eastern Bypass Road.
Date of Earthworks / Rehabilitation	2006
Earthworks Contractor	Ozon/Jim Seeds
Ripping Depth	
Growth Medium Used	oxide
Growth Medium Depth	
Pioneer Seed Mix	Oxide pioneer seed mix seeded April 2007
Secondary Seed Mix	
Seed Application	Hand seeded
Soil Treatments (eg gypsum, mulch)	none
EFA Monitoring Schedule	January
EFA Assessor	NG (2007) AW & LP (2009)
GPS Coordinates of Transects (GDA 94 51 J)	Transect 1: 51 J 0358090E 6594514N Transect 2: 51 J 0358075E 6594369N Transect 3: 51 J 0357923E 6594324N
Aspect	T1-Eastern; T2-Southern; T3-Western
Slope Angle	All transects 15°.

Location of site:



Rehabilitation trends:

Criteria	2007 mean	2009 mean	2007 comparison to 2009	Comments
Stability (%)	52	53.8	Increased	Increased slightly despite break in berms near T3. High plant density increased stability result
Infiltration (%)	43.1	17.7	Decreased	Decrease despite high rainfall for Jan 09. Low vegetation cover and leaf litter accumulation preventing resource retention
Nutrient Cycling (%)	30.3	12.8	Decreased	Low vegetation cover and leaf litter accumulation preventing resource retention. High level of run off from T3
Species Density (plants/10m ²)	32	79	Increased	Greatest increase in T2. Increased despite worsening conditions (ie. low nutrients/infiltration). More plants becoming established 2 years post seeding
Species Diversity (plants/10m ²)	4	8	Increased	<i>Chenopodiaceae</i> family most dominant.
Weed Density (plants/10m ²)	0	0	Same	No weed species found from 2007-2009
Growth Medium pH	N/A	8.1	N/A	Low Acidity
Growth Medium Ec (mS/m)	N/A	470.1	N/A	High soil salinity

