MONITORING OF

VEGETATION DIRECT TRANSFER TRIAL

AT ENEABBA OPERATIONS, JENNINGS AREA

Prepared By

Mattiske Consulting Pty Ltd

Prepared For

ILUKA RESOURCES LTD

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LIST OF ABBREVIATIONS

BAM Act:	*Biosecurity and Agriculture Management Act 2007* (WA)
BC Act:	*Biodiversity Conservation Act 2016* (WA)
BOM:	Bureau of Meteorology
DotEE:	Department of the Environment and Energy
DBCA:	Department of Biodiversity, Conservation and Attractions
DPaW:	Department of Parks and Wildlife (now under DBCA)
DPIRD:	Department of Primary Industries and Regional Development (includes Agriculture and Food)
EP Act:	*Environmental Protection Act 1986* (WA)
EPA:	Environmental Protection Authority
EPBC Act:	*Environment Protection and Biodiversity Conservation Act 1999* (Commonwealth)
Iluka:	Iluka Resources Ltd
LTA:	Long Term Average
VDT	Vegetation Direct Transfer
WAH:	Western Australian Herbarium (PERTH)
WAOL:	Western Australian Organism List

EXECUTIVE SUMMARY

Mattiske Consulting Pty Ltd was commissioned in August 2019 by Iluka Resources Ltd to conduct further monitoring of the Vegetation Direct Transfer trial, which encompasses a rehabilitation technique that was first implemented at Iluka Eneabba in 2012. The primary aim of trialling this direct transfer technique was to assess the survivorship of rushes, sedges and herbaceous species. In particular, resprouting individuals whose representation within rehabilitation is often far less than occurs in natural vegetation. The results of this trial will assist in addressing the annual reporting needs required of Iluka Resources Ltd under the *Mineral Sands (Eneabba) Agreement Act 1975*.

A total of 130 vascular plant taxa which are representative of 66 plant genera and 28 plant families were recorded within the 16 trial Vegetation Direct Transfer transects in 2019. Of the 130 taxa recorded, five were introduced species. No threatened flora and five priority flora (*Comesperma rhadinocarpum*, *Desmocladus elongatus*, *Hemiandra* sp. Eneabba (H. Demarz 3687), *Hypocalymma gardneri* and *Schoenus griffinianus*) were recorded within the Vegetation Direct Transfer trial.

The mean alive native foliage cover has markedly increased within all four treatments, with all of the treatments seeing an increase of over double the mean alive native foliage cover recorded during the 2019 monitoring. Total species richness excluding introduced species decreased within all four treatments since the 2015 monitoring. This is most likely due to a reduction in annual species seen in 2019 compared to 2015. A reduction in annual species in this year's survey can be attributed to reduced rainfall and increased temperatures in the three months preceding the survey. Total species richness including introduced species also decreased within all four treatments for the same reasons.

The proportion of alive plants by growth form has varied throughout the survey years. In this year's monitoring the proportion of perennial herbs and shrubs have increased compared to previous years, while annual grasses and annual herbs have decreased in the current survey compared to previous years. This difference is largely due to the decrease in density of annual herbs such as *Gnephosis tenuissima* and *Levenhookia* spp. These species were recorded last year in wetter areas between the translocated sods of vegetation, where micro-habitats had been created due to the excessive water content within the soil.

Between 2012 and 2014 within all four treatments there was a noticeable increase in the proportions of alive seeder species and a reduction in the proportions of alive resprouter species. However, the 2015 and 2019 surveys have seen an increasing trend within all four treatments, in the proportions of alive resprouter species, with a concurrent reduction in the proportions of alive seeder species. This is encouraging given that recalcitrant (cannot be propagated easily from seed or vegetatively) resprouter species from the families *Cyperaceae* and *Restionaceae* have often been absent in past rehabilitated areas using differing techniques to the Vegetation Direct Transfer trial.

A few notable anecdotal observations were recorded during monitoring in 2019. There were generally high numbers of resprouting plants and additional regeneration across the majority of the Vegetation Direct Transfer trial area. There was an overall increase in foliage cover, shrubs were observed to be resprouting, and in particular, *Adenanthos cygnorum* was noticeably larger than previous monitoring years. The continual presence of the tuberous species such as *Haemodorum* and *Thysanotus* was also observed. Furthermore, an increase in shrub growth and soil-binding sedges and rushes has resulted in an increase in soil stabilisation, and a reduction in water and wind driven soil erosion which was observed in previous monitoring years. It appears from quantitative results and anecdotal observations that there is a good level of regeneration of rush and sedge species this year, in addition to the large increase in foliage cover for shrub species.

Overall it appears that treatment 1 fared worse than the other treatments, as indicated by treatment 1 containing; less foliage cover, less resprouter species, the least mean alive density of plants per square meter and the highest number and density of introduced species. As a whole, eight years since the vegetation has been translocated there appears to be little difference in the effect of treatment on the

receiving vegetation. The vegetation in all of the treatments have undergone a very high level of stress, but appear to be regenerating, with significantly increased foliage cover and reduced levels of erosion observed in the current survey. However, it must be noted that some key dominant species found in undisturbed kwongan such as *Banksia* and *Petrophile* species are yet to become apparent in the vegetation structure.

Following the assessment of the Vegetation Direct Transfer rehabilitation technique trial in the Jennings area by Iluka Eneabba, it is recommended that monitoring of the Vegetation Direct Transfer transects continues, to further elucidate the effects of each treatment on the flora and vegetation and to determine if further regeneration of rushes and sedges continues to occur. This will also allow for evaluation as to the effectiveness of Vegetation Direct Transfer as a viable, larger-scale technique for use at Iluka Eneabba Operations and to gain further insight into the successive stages of the translocated rehabilitation.

1. INTRODUCTION

Mattiske Consulting Pty Ltd (Mattiske) was commissioned in August 2019 by Iluka Resources Ltd (Iluka) to conduct monitoring of sixteen Vegetation Direct Transfer (VDT) trial transects that were established in October 2012. The Iluka Sand Mine at Eneabba is largely located on land agreements and as such comes under the *Mineral Sands (Eneabba) Agreement Act 1975* which states:

- Iluka is obliged to comply with all legislation (State and Commonwealth) with respect to protection of the environment; and
- Iluka is required to protect and manage the environment, including the rehabilitation and/or restoration of the mined areas.

Iluka is required to undertake a continuous programme of investigation and research (including monitoring and the study of sample areas) to measure the effectiveness of environmental protection and management on site. The results of the investigations are to be reported annually and triennially.

1.1. Location and Scope of Project

The Iluka Sand Mine is located within the GES02 - Lesueur Sandplain subregion of the Geraldton Sandplains Interim Biogeographical Region (Desmond and Chant 2001). The region is comprised of mainly proteaceous heaths and scrub-heaths ('kwongan' vegetation) on sandy earths on undulating sandplains. The region is rich in endemics as well as supporting threatened, priority and poorly described taxa (Desmond and Chant 2001). The sixteen trial VDT transects are situated within Iluka Eneabba's former Jennings mining area, located north of the Eneabba townsite, accessible via the North Mine (Twin Hills) entrance. The Jennings northern extension is bordered by native vegetation on the east and west, providing a linkage between the *in-situ* native areas.

Initial monitoring of the trial VDT transects was conducted by Mattiske in October 2012 (Mattiske Consulting Pty Ltd 2012a) to collect baseline data on Iluka's newly established trial VDT rehabilitation, as part of its commitment to broadening and improving rehabilitation success at the Iluka Resources Eneabba Operations. This trial also aims to determine the effectiveness of this technique in improving the survivorship of sedge, rush and herbaceous species. If successful, the VDT trial will enable rehabilitation that replaces the intact original vegetation, soil and its associated seedbank.

In February 2012, primary rehabilitation earthworks commenced at the former Jennings mining area, where approximately 28 hectares of land was re-vegetated utilising both seed and propagative resources. Throughout the work, two hectares was reserved to trial the VDT rehabilitation technique, which had yet not been implemented at Iluka Eneabba Operations. This rehabilitation technique involved the physical re-location of sods of vegetation to an adequate receiving area, approximately 1.6 ha in size.

1.2. Environmental Legislation and Guidelines

The following key Commonwealth (federal) legislation relevant to this survey is the:

- *Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act).*

The following key Western Australian (state) legislation relevant to this survey include the:

- *Biodiversity Conservation Act 2016* (*BC Act*);
- *Biodiversity Conservation Regulations 2018;*
- *Biosecurity and Agriculture Management Act 2007* (*BAM Act*);
- *Biosecurity and Agriculture Management Regulations 2013*;
- *Environmental Protection Act 1986* (*EP Act*); and

Furthermore, key Western Australian guidelines relevant to this survey are the:

- *Technical Guidance – Flora and vegetation surveys for environmental impact assessment* (Environmental Protection Authority [EPA] 2016a).
- *Environmental Factor Guideline: Flora and Vegetation* (EPA 2016b); and

Definitions of flora and vegetation terminology commonly used throughout this report are provided in Appendix A1-3.

2. BACKGROUND

2.1. Vegetation Direct Transfer as a Rehabilitation Technique

The rehabilitation technique of VDT, or community translocation, is the practice of salvaging and replacing intact sods of vegetation with the underlying soil intact (Ross *et al*. 2000). Rehabilitation practices in earlier years often involved bringing the disturbed area back to pastoral land or 'exotic' forestry products, instead of local, native vegetation. However over time, there has been a shift towards restoring indigenous ecosystems on disturbed sites (Ross *et al*. 2000). Successful examples of utilising VDT in rehabilitation have shown rapid recovery of indigenous vegetation cover and conservation of the habitat. However some recorded failures have resulted from excessive death of plants due to inadequate soil salvage depths, acidic leachates, poor handling of stripped sods and prolonged drought following transfer (Ross *et al*. 2000). Despite recorded failures, there are numerous advantages to utilising direct transfer as a rehabilitation technique, such as: recycling of plant and soil materials; faster re-vegetative process; restoration of the whole ecosystem; and erosion control (Ross *et al*. 2000). Intrinsically, however, there are a few common problems that may occur as a result of this technique such as: the direct transfer onto over-compacted soils; the exposure of vegetation roots; inappropriate handling of the vegetation; and environmental stresses post transfer (Ross *et al*. 2000).

The use of this technique by Iluka in the former Jennings mining area aims to improve the sustainability of translocating largely recalcitrant sedge and rush species, which tend to be less well represented in rehabilitation via other techniques, due to their low or complete lack of seed production (Norman and Koch 2007), but which often dominate local heath communities. The use of deep profile direct return of the topsoil and overburden in one pass may provide a large scale method of translocating rhizomatous and tuberous species in rehabilitated areas (Norman and Koch 2007).

Increasing the representation of resprouter species is a key issue in restored areas, because the density of resprouters often differs largely between rehabilitated and unmined areas (Grant and Loneragan 1999; Norman and Koch 2007). In a study conducted at Eneabba, Herath *et al*. (2009) reported that there was lower restored resprouter densities of just 4 individuals/m² compared to 7 – 15 individuals/m² in natural surrounding vegetation. Whilst the establishment of resprouting species is not the main purpose for trialling VDT at the former Jennings mining area, establishing mature resprouter species would be a highly beneficial secondary outcome. Therefore, if the VDT technique proves to be successful, it will allow for increased representation of recalcitrant species in rehabilitated sites, resulting in a floristic composition that is more comparable to that of surrounding native areas.

Similar work has been trialled by Iluka at the Tutunup South Mineral Sands Mine, which was assessed by Mattiske (2012b). The results of this preliminary study, along with research conducted by Norman and Koch (2007) in the Jarrah forest, and studies conducted in New Zealand (in a synthesis by Ross *et al*. 2000) have been broadly extrapolated to this study.

2.2. Climate

Beard (1990) described the climate of the Irwin Botanical District as dry, warm Mediterranean, with winter rainfall of approximately 300 – 500 mm annually. The average minimum temperature for Carnamah (60 km from Eneabba) for October 2018 to September 2019 generally followed long term average (LTA) minima trends, whilst the average monthly maximum temperatures were generally higher than the LTA maxima. Rainfall recorded for the year preceding the survey was highly variable in comparison to the LTA rainfall. Rainfall recorded in June 2019 was noticeably higher than the LTA, with 161.2 mm rainfall received compared to the LTA of 107.7 mm for June. Comparatively, the months of July to September 2019 received less than half the LTAs for rainfall (88.6 mm rainfall received cf. LTA of 200.5 mm). Total rainfall for the period October 2018 to September 2019 was 288.6 mm, which is markedly lower than the LTA of 484.8 mm for the same period.

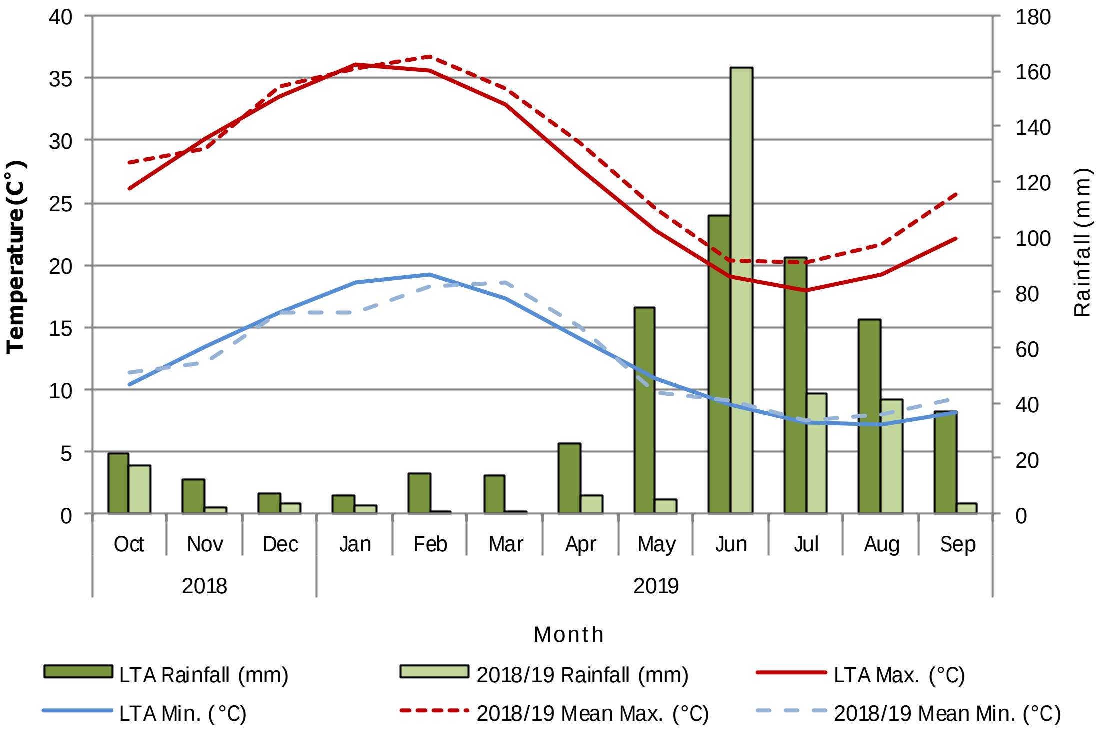


Figure 1: Rainfall (Green Grove) and temperature data (Carnamah)
Long term average rainfall and temperature data, together with monthly rainfall and average maximum and minimum temperature data for the period October 2018 to September 2019 (Bureau of Meteorology 2019).

3. OBJECTIVES

The aim of this monitoring was to conduct a flora and vegetation assessment of the 16 VDT transects. The VDT rehabilitation technique was trialled to assess the survivorship of sedge, rush and herbaceous species. Specifically, the objectives included:

- re-monitor the sixteen transects within the trial VDT area;
- record or collect and identify the vascular plant species present within the trial VDT area;
- review the conservation status of the vascular plant species recorded by reference to current literature and current listings by the DBCA (2019a) and plant collections held at the Western

Australian State Herbarium (WAH 1998-), and listed by the DotEE (2019a) under the *Environment Protection and Biodiversity Conservation Act 1999*;

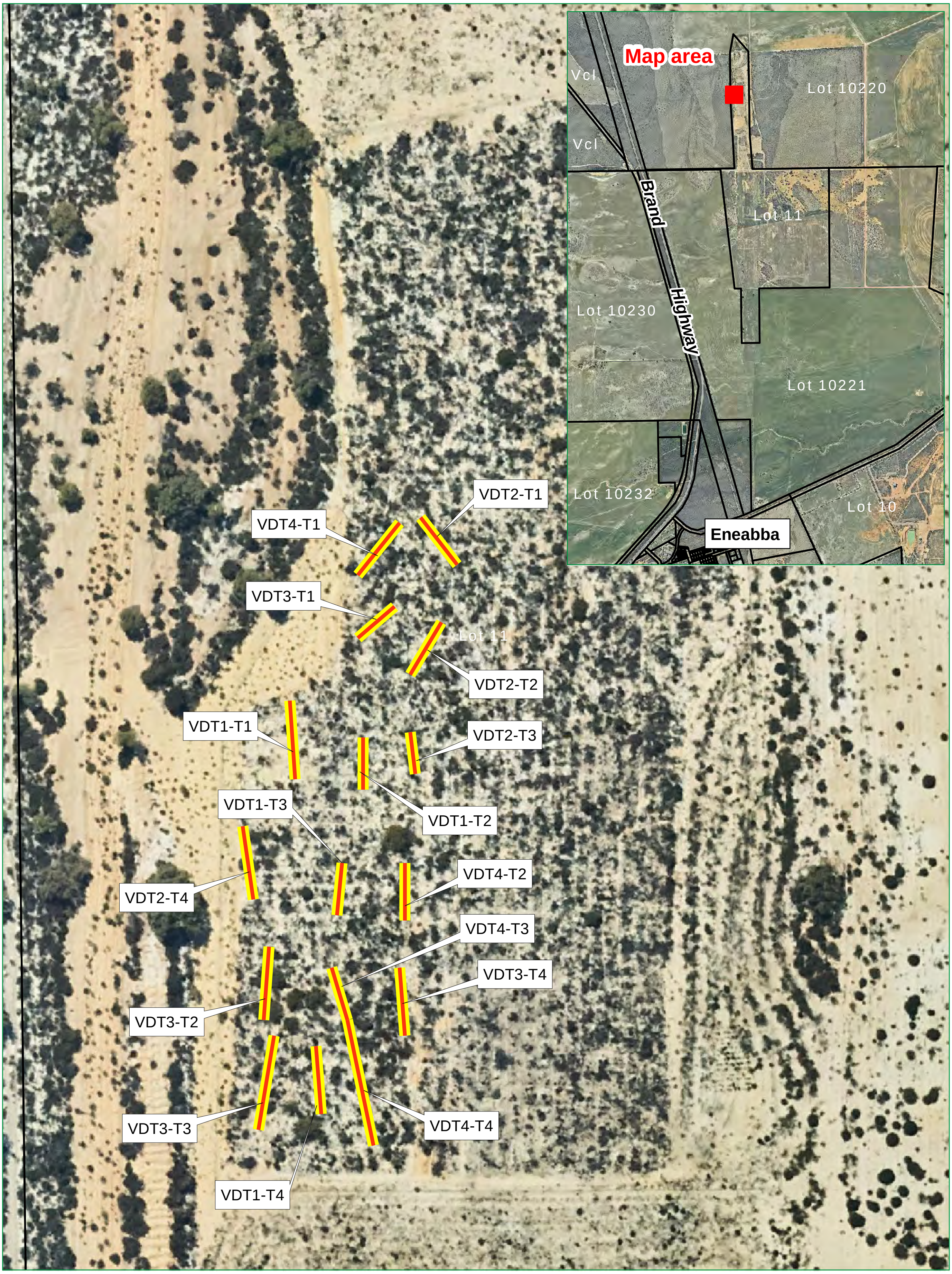
- collect quantitative data used to calculate plant density, foliage cover and species richness to compare the effects of the four treatments applied to the translocated vegetation;
- assess the contribution of resprouter and seeder individuals in each treatment;
- assess the proportional representation of growth forms in each treatment;
- provide comments on the current status of the translocated vegetation;
- provide any anecdotal observations recorded in the field;
- provide recommendations in response to results of the 2019 monitoring; and
- prepare a report summarising the findings.

4. METHODS

Monitoring of the 16 trial VDT transects within Iluka's former Jennings mining area was undertaken by four experienced botanists from Mattiske Consulting Pty Ltd on the 7th and 8th of October 2019. All botanists held valid collection licences to collect flora for scientific purposes, issued under the *Biodiversity Cons*ervation Act 2016. The survey work was carried out in accordance with methods outlined in Technical Guidance – Flora and vegetation surveys for environmental impact assessment (EPA 2016a)

4.1. Transect Design and Monitoring

The VDT transects were established within the allocated trial VDT rehabilitation area (Figure 2) located within the former Jennings mining area (Table 1) during February 2012. Each of the 16 transects are 12 metres long and pegged at each end, with both the start and end peg of each transect being labelled appropriately. A total of 12 quadrats were sampled along the length of each transect. Methodology for quadrat placement along each transect is illustrated in Figure 3.



N

0 10 20 m

Aerial photo - 27 Aug. 2019

Legend

VDTs

ENEABBA

VDT trial transects layout

ILUKA

ORIG: S.Barron DRAWN: D.G.S. SCALE (A4): 1:1,000 DATE: 22 Nov. 2019 DWG No: 257654 ver.00

FIGURE: 2

Four VDT treatments were applied to the translocated vegetation within the trial VDT area during 2012 at Iluka's former Jennings mining area:

1. Slashed with the application of Envy transpiration blocker
2. Slashed without the application of Envy transpiration blocker
3. Control (no treatment)
4. No slashing with the application of Envy transpiration blocker

A total of 16 transects are located within the trial VDT area, of which there are four transects for each of the four treatments. The vegetation was slashed prior to transfer, whilst the Envy transpiration blocker (AgroBest 2012) was applied *in situ* after translocation.

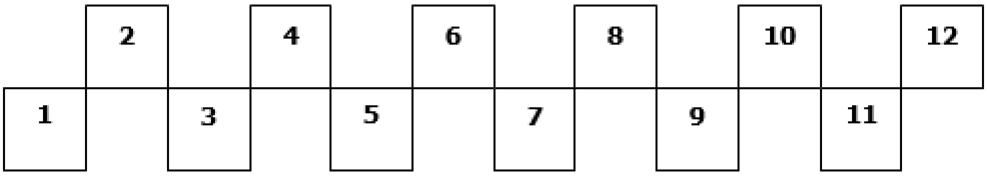


Figure 3: Quadrat arrangement along the VDT transects

Each quadrat measured one metre by one metre. Within each quadrat the following was recorded:

- species (or a collection if species unknown), whether rooted in or overhanging the quadrat;
- number of alive and dead individuals rooted within each quadrat for each recorded species;
- alive and dead percentage foliage cover for each species, whether rooted in or overhanging the quadrat; and
- any additional anecdotal observations.

At the start and end of each transect photographs were taken to provide a long term photographic record. Anecdotal observations on the overall appearance of the vegetation within each transect was recorded. In addition, the presence of any bare patches, drainage channels, compaction of the soil and any observed exposure of plant roots was also recorded.

All plant specimens collected during monitoring were dried and processed in accordance with the requirements of the Western Australian Herbarium. Plant species were identified through comparisons with pressed specimens housed at the Western Australian Herbarium. Where appropriate, plant taxonomists with specialist skills were consulted. Nomenclature of the species recorded is in accordance with the Western Australian Herbarium (WAH 1998-).

Table 1: Start GPS locations of VDT transects monitored in 2019

Treatment	Transect	Geographic Location (GDA94_Z50)	
		Easting	Northing
VDT1	1	333291	6705615
	2	333300	6705613
	3	333295	6705589
	4	333297	6705551
VDT2	1	333312	6705654
	2	333319	6705633
	3	333310	6705615
	4	333284	6705581
VDT3	1	333309	6705641
	2	333285	6705571
	3	333285	6705551
	4	333309	6705567
VDT4	1	333309	6705651
	2	333309	6705589
	3	333300	6705569
	4	333305	6705543

4.2. Data Analysis

Alive and dead plant density (per m^2), alive and dead foliage cover (%) and total species richness (total species per treatment, presented with and without introduced species) were calculated for all transects and presented as a mean ± standard error per treatment. Plant density, foliage cover and species richness calculations are for both alive and dead native plants only, with alive plant density of introduced species presented separately. Additionally, annual species were also excluded from density and foliage cover analyses due to their high numbers within each quadrat which results in noticeably higher densities per treatment than when excluded. This allows for results to be more reflective of those desired to be presented (i.e. perennial species). All recorded species were assigned a growth form category, which was then used to illustrate the counts of each alive and dead growth form for each treatment. Growth form categories were obtained from the Western Australian Herbarium (WAH 1998-). The percentage contribution of resprouter and seeder species to each treatment is also presented. Seeder refers to obligate seeder species only and resprouter broadly refers to any species that possesses a lignotuber or bulb, regardless of whether it is an obligate-vegetatively reproducing (OV) or auto-regenerating long-lived (AL) species. Available data on individual species' growth strategy was obtained from the Iluka nursery database (C. Payne pers. comm.), the Western Australian Herbarium (WAH 1998-), Bell (2001) and Herath *et al*. (2009). The comparative proportions of native species and introduced species were also calculated and presented for each treatment.

The Shannon-Wiener Diversity Index (H') (from Brower and Zar 1977) was used to calculate species diversity for each VDT treatment. The Shannon-Wiener Diversity Index (H') was calculated for both density and foliage cover parameters.

$$H' = -\sum p_i \log p_i \text{ where } p_i = n_i/N$$

Where:

p_i = the proportion of the total number of individuals occurring in species i

n_i = the number of individuals of species i

N = the total number of individuals of all species in the population (plot)

5. RESULTS

5.1. Flora

A total of 130 vascular plant taxa which are representative of 66 plant genera and 28 plant families were recorded within the 16 trial VDT transects in 2019. The majority of the taxa recorded were representative of the Cyperaceae (17 taxa), Myrtaceae (15 taxa) and Fabaceae (12 taxa) families (Appendix B).

5.1.1. Threatened and Priority Flora

No threatened flora pursuant to the *EPBC Act* and as listed by the DBCA (2018a) were recorded within the VDT trial rehabilitation transects. No threatened flora pursuant to the *Environment Protection and Biodiversity Conservation Act 1999* and as listed by the DotEE (2019a) were recorded within the trial VDT transects.

Five priority flora species as listed by the Western Australian Herbarium (WAH 1998-) were recorded within the trial VDT transects (Appendix B). Seven individuals of *Comesperma rhadinocarpum* (P3), one individual of *Hemiandra* sp. Eneabba (H. Demarz 3687) (P3), two individuals of *Hypocalymma gardneri* (P3), 11 individuals of *Desmocladus elongatus* (P4) and ten individuals of *Schoenus griffinianus* were located across all four treatments (Table 2). A brief description of each is provided below.

Comesperma rhadinocarpum (P3) POLYGALACEAE

An erect perennial herb to 45 cm high, with linear-elliptic leaves. It produces blue flowers in slender racemes from October to December and occurs in sandy soils (Grieve 1998; WAH 1998-). The Western Australian Herbarium has 16 specimens in its records (DPaW 1998-).

Hemiandra sp. Eneabba (H. Demarz 3687) (P3) LAMIACEAE

A straggly, erect shrub, 50 to 90 cm high, to 40 cm wide. Flowers blue/violet in February. Occurs on sand soils and disturbed sites (WAH 1998-). The Western Australian Herbarium has 34 specimens in its records (DPaW 1998-).

Hypocalymma gardneri (P3) MYRTACEAE

A shrub, to 30 cm high. Flowering yellow between August and September. Occurring on grey-brown sand and laterite within sandplains, upper slopes and heathland (WAH 1998-). The Western Australian Herbarium has 22 specimens in its records (WAH 1998-).

Desmocladus elongatus (P4) RESTIONACEAE

A rhizomatous, perennial, sedge-like herb from 25 to 50 cm high. It produces flowers from August to December and occurs in white or grey sand in dry kwongan. The Western Australian Herbarium has 43 specimens in its records (WAH 1998-).

Schoenus griffinianus (P4) CYPERACEAE

A small, tufted perennial, grass-like or herb (sedge), to 10 cm high. It produces flowers from September to October and occurs in white sand. The Western Australian Herbarium has 38 specimens in its records (WAH 1998-).

Table 2: Transect start GPS locations for priority flora recorded within the VDT monitoring trial during 2019
Note: Population number in brackets indicates the number of dead individuals.

Species	VDT Treatment	Transect	Geographic Location (GDA94_Z50)		Population
			Easting	Northing	
Comesperma rhadinocarpum (P3)	VDT1	T2	333302	6705612	2
	VDT2	T3	333311	6705613	2 (1)
	VDT4	T1	333309	6705653	2
Hemiandra sp. Eneabba (H. Demarz 3687) (P3)	VDT3	T1	333308	6705637	1
Hypocalymma gardneri (P3)	VDT2	T2	333317	6705634	1
	VDT2	T4	333279	6705595	1
Desmocladus elongatus (P4)	VDT1	T3	333298	6705588	2
	VDT2	T1	333313	6705654	1
	VDT2	T2	333317	6705634	1
	VDT2	T3	333311	6705613	1
	VDT2	T4	333279	6705595	1
	VDT3	T1	333308	6705637	(1)
	VDT3	T2	333284	6705572	1
	VDT3	T4	333309	6705568	1
	VDT4	T1	333309	6705653	1
	VDT4	T4	333304	6705534	1
Schoenus griffinianus (P4)	VDT1	T4	333293	6705553	1
	VDT2	T1	333313	6705654	4 (1)
	VDT2	T2	333317	6705634	1
	VDT2	T3	333311	6705613	1
	VDT4	T2	333310	6705588	1
	VDT4	T4	333304	6705534	1

5.1.2. Introduced (Weed) Species

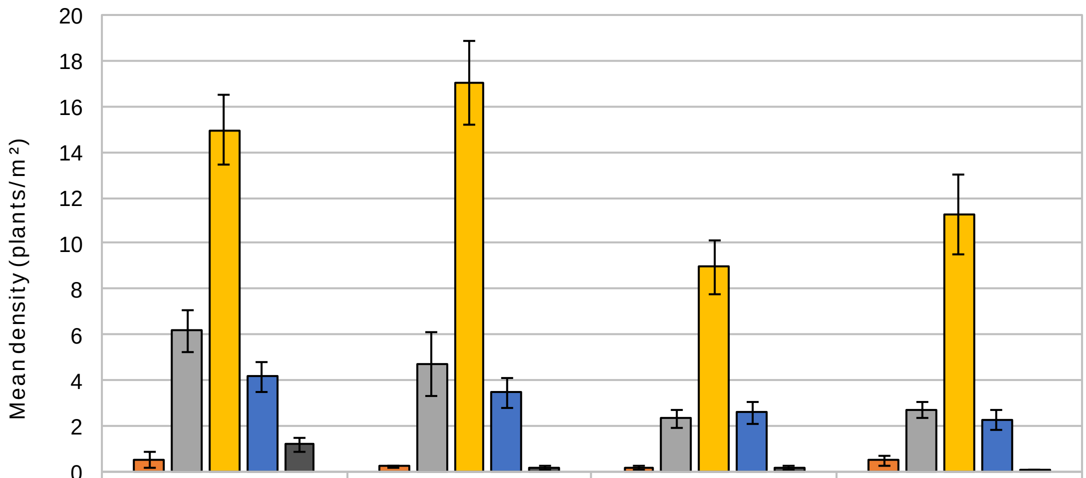
A total of five introduced (exotic) plant species were recorded within the trial VDT transects (Table 3), down from 10 species recorded in 2015 (Mattiske 2015). None of these species are declared pest organisms pursuant to section 22 of the *BAM Act* (Department of Primary Industries and Regional Development 2019) and none are Weeds of National Significance (DotEE 2019b).

All four VDT treatments contained introduced species, with the incidence of introduced species noticeably increasing over the years up to 2014, where a large increase in mean alive introduced species density was seen. However there was a reduction in alive introduced species density recorded during the 2015 monitoring and this year's monitoring (Figure 4; Figure 5). Treatment 1 had the highest mean alive introduced species density (1.17 ± 0.33 plants/m², compared with treatment 1 in 2015 at 4.13 ± 0.63 plants/m²) with all five introduced species being recorded in transects with this treatment (Table 3). Comparatively, treatment 4 had the lowest mean alive introduced species density (0.02 ± 0.02 plants/m², compared with treatment 4 in 2015 at 2.25 ± 0.42 plants/m²), with only one of the five introduced species being recorded in transects with this treatment (Table 3). Overall there was little difference in the number of introduced species recorded between all treatments (Figure 5). All four treatments showed a reduction in the numbers of introduced species since the previous monitoring in 2015 (Figure 5). Despite the incidence of introduced species occurring within the VDT area, there continues to be a markedly higher proportion of native species than introduced species, ranging from 93.63% mean native species contribution in treatment 1 up to 99.97% in treatment 4 (Figure 5).

Table 3: Introduced species recorded within each VDT treatment monitored in 2019

Introduced Species	VDT Treatment			
	VDT1	VDT2	VDT3	VDT4
**Arctotheca calendula*	x		x	
**Ehrharta calycina*	x			
**Hypochaeris glabra*	x	x	x	x
**Ursinia anthemoides* subsp. *anthemoides*	x		x	
**Wahlenbergia capensis*	x	x		

The predominant introduced species across all four treatments were **Hypochaeris glabra* (44 individual plants), **Ursinia anthemoides* subsp. *anthemoides* (13 individual plants) and **Ehrharta calycina* (7 individual plants). **Arctotheca calendula* and **Wahlenbergia capensis* were recorded in two treatments each and each species had 5 individual plants recorded.



	VDT1	VDT2	VDT3	VDT4
2012	0.50	0.20	0.13	0.45
2013	6.15	4.69	2.29	2.67
2014	14.98	17.04	8.94	11.27
2015	4.13	3.44	2.56	2.25
2019	1.17	0.13	0.15	0.02

Treatment

Figure 4: Mean alive introduced species density (plants/m²) ± s.e. per VDT treatment during 2012, 2013, 2014, 2015 and 2019

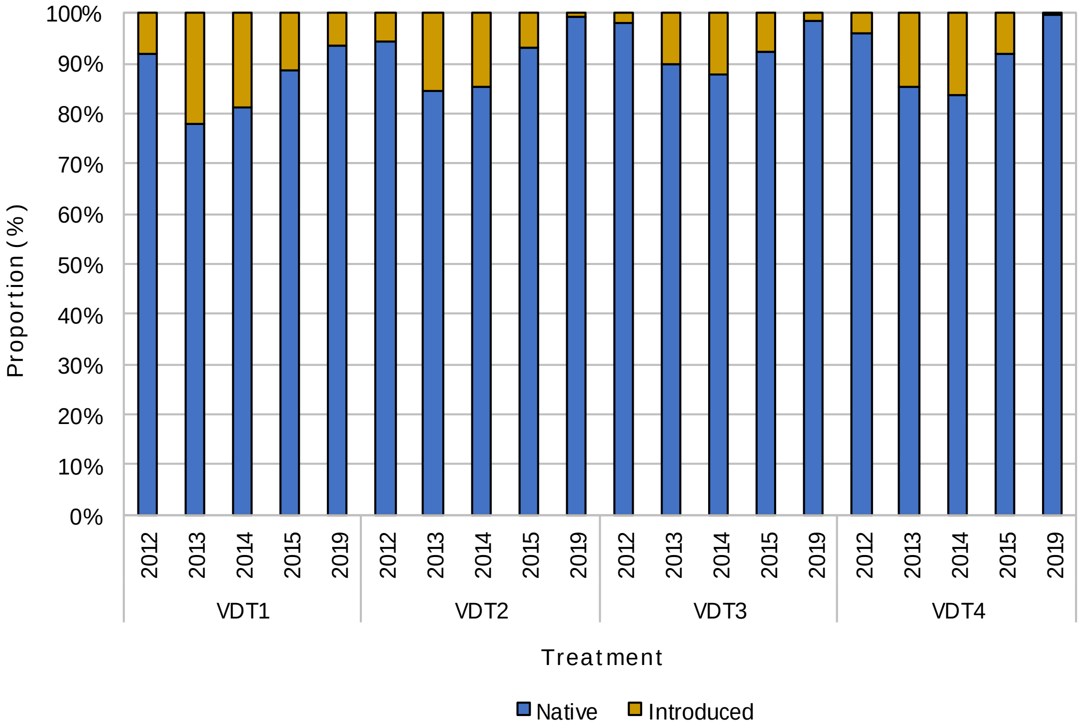


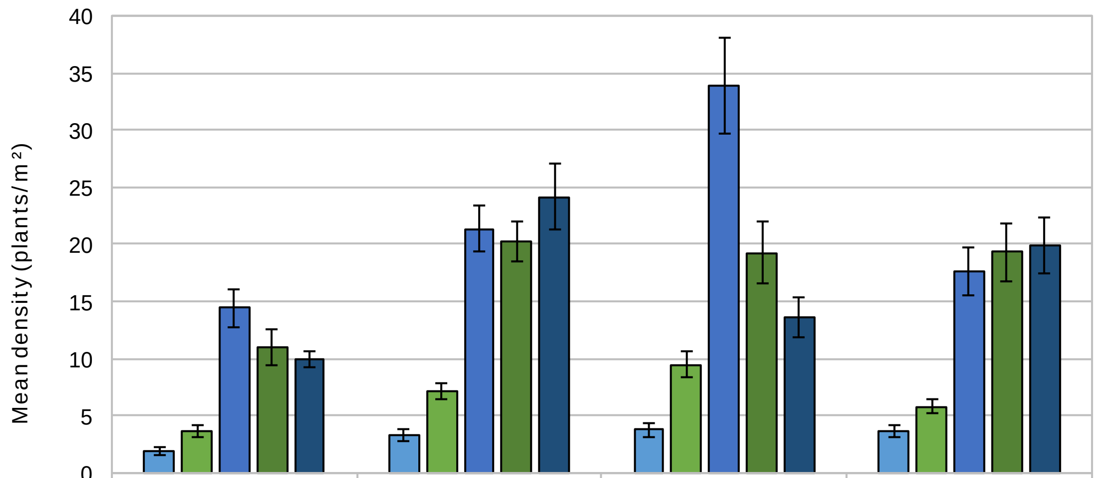
Figure 5: Proportion (%) of native versus introduced species per VDT treatment during 2012, 2013, 2014, 2015 and 2019

5.2. Comparison of VDT Treatments

5.2.1. Density, Foliage Cover and Species Richness

Mean alive plant densities decreased in VDT treatments 1 and 3 and increased in treatments 2 and 4, since the monitoring in 2015 (Figure 6). Treatment 2 had the highest mean alive native plant density, whilst treatment 1 had the lowest (24.13 ± 2.90 and 9.85 ± 0.70 plants/m² respectively). Mean dead native plant densities (Figure 7) showed an increase within treatments 1, 2, and 4 and a decrease in treatment 3 since 2015 monitoring. Treatment 3 had the lowest mean dead plant density whilst treatment 4 had the highest (1.20 ± 0.16 and 2.11 ± 0.42 plants/m² respectively).

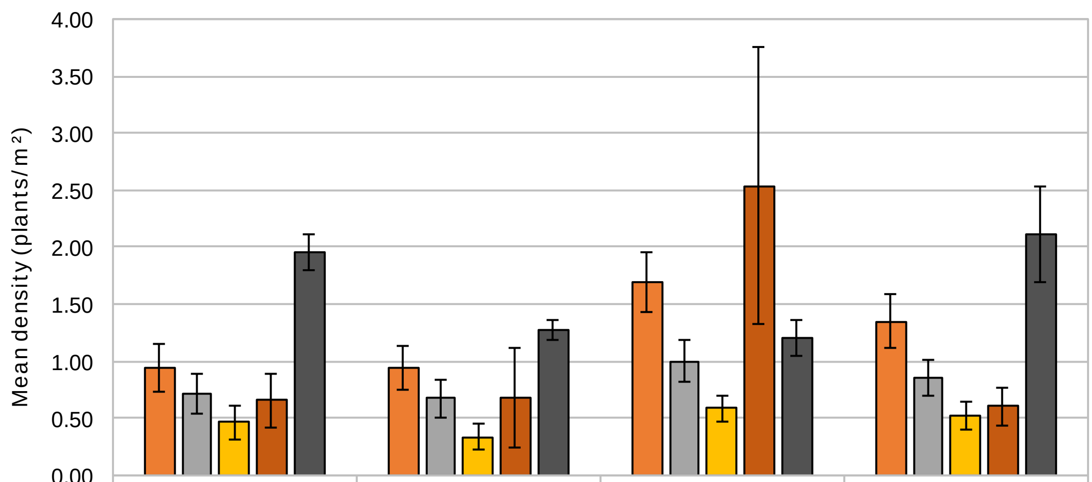
Mean alive native foliage cover had markedly increased within all four treatments since 2015 (Figure 8). Results of this year's monitoring continue the increasing trend seen in previous years, with treatment 3 having the highest mean alive native foliage cover of 68.05 ± 5.09 %, an increase of over double the mean alive native foliage cover recorded during the 2015 monitoring. The lowest mean alive foliage cover was recorded within treatment 1, with a mean alive coverage of 30.80 ± 3.14 %, this has also more than doubled in mean native foliage cover. Mean dead foliage cover recorded this year saw an overall increase in comparison to 2015 monitoring (Figure 9), with treatments 3 and 4 having the highest mean dead foliage cover (6.07 ± 0.75 % and 12.50 ± 2.59 % respectively). Treatment 2 had the lowest mean dead foliage cover with 3.49 % (± 0.62).



	VDT1	VDT2	VDT3	VDT4
2012	1.90	3.19	3.75	3.63
2013	3.63	7.04	9.44	5.77
2014	14.38	21.33	33.83	17.63
2015	10.98	20.23	19.23	19.29
2019	9.85	24.13	13.60	19.87

Treatment

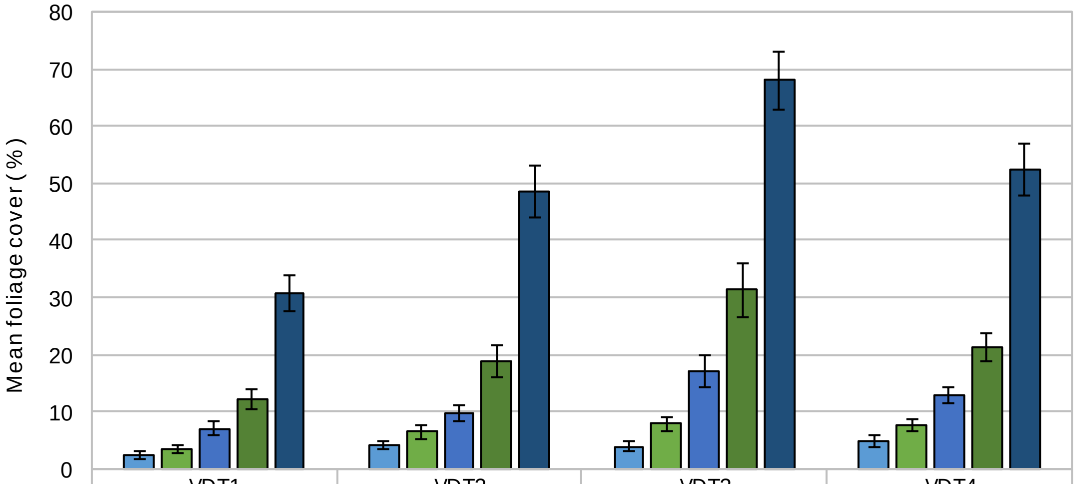
Figure 6: Mean alive plant density (plants/m²) ± s.e. per VDT treatment during 2012, 2013, 2014, 2015 and 2019 (excluding introduced and annual species)



	VDT1	VDT2	VDT3	VDT4
2012	0.94	0.94	1.69	1.35
2013	0.71	0.67	1.00	0.85
2014	0.46	0.33	0.58	0.52
2015	0.65	0.67	2.54	0.60
2019	1.96	1.27	1.20	2.11

Treatment

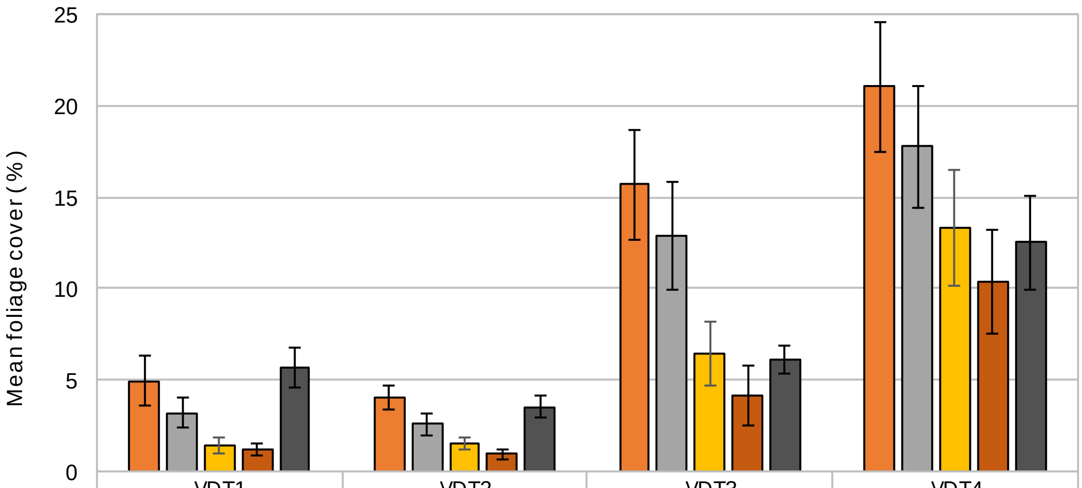
Figure 7: Mean dead plant density (plants/m²) ± s.e. per VDT treatment during 2012, 2013, 2014, 2015 and 2019 (excluding introduced and annual species)



	VDT1	VDT2	VDT3	VDT4
2012	2.34	4.04	3.78	4.73
2013	3.4	6.37	7.76	7.44
2014	6.92	9.62	17.01	12.81
2015	12.13	18.68	31.22	21.17
2019	30.80	48.56	68.05	52.41

Treatment

Figure 8: Mean alive foliage cover (%) ± s.e. per VDT treatment during 2012, 2013, 2014, 2015 and 2019 (excluding introduced and annual species)



	VDT1	VDT2	VDT3	VDT4
2012	4.93	4.03	15.67	21.06
2013	3.18	2.53	12.87	17.76
2014	1.42	1.49	6.39	13.29
2015	1.16	0.89	4.12	10.36
2019	5.65	3.49	6.07	12.50

Treatment

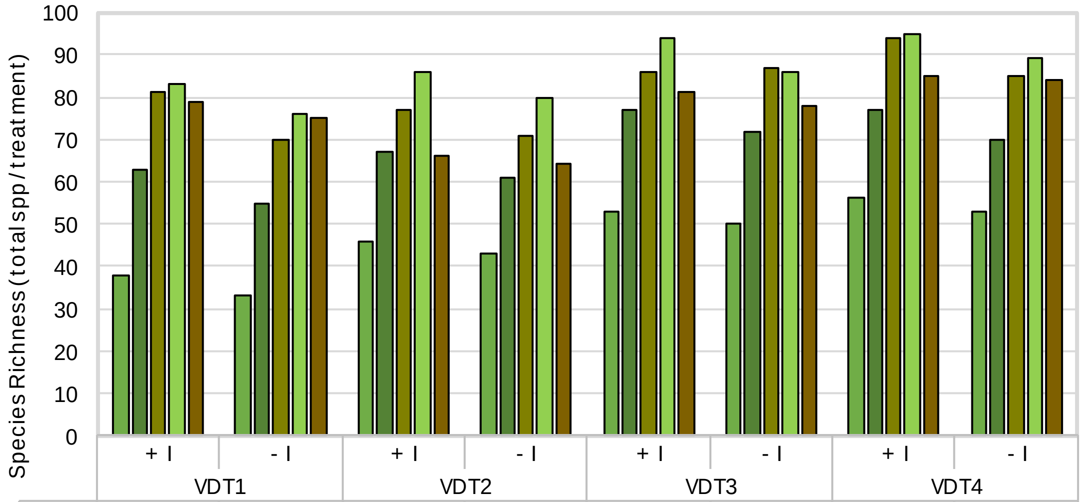
Figure 9: Mean dead foliage cover (%) ± s.e. per VDT treatment during 2012, 2013, 2014, 2015 and 2019 (excluding introduced and annual species)

The Shannon-Weiner diversity indices (H') for density increased within all treatments between 2015 and 2019, with the exception of treatment 2 (2.40 and 2.01 respectively). The Shannon-Weiner diversity indices (H') for foliage cover showed a reduction in all treatments between 2015 and 2019, with the exception of treatment 3, which increased (2.62 and 2.86 respectively) (Table 4). Treatment 3 had the highest H' value for density and foliage cover during 2019 (2.93 and 2.86 respectively). Comparatively, treatment 2 had the lowest H' value for density (2.01) and had the lowest H' for foliage cover (2.76) during 2019.

Table 4: Comparison of Shannon-Weiner Diversity Indices (H') for alive plant density and foliage cover for each VDT treatment during 2012, 2013, 2014, 2015 and 2019

VDT Treatment	Shannon-Weiner Diversity Indices (H')									
	Density					Foliage Cover				
	2012	2013	2014	2015	2019	2012	2013	2014	2015	2019
VDT1	2.03	2.53	2.41	2.32	2.47	2.06	2.79	3.06	2.98	2.85
VDT2	3.03	2.93	2.72	2.40	2.01	2.81	3.30	3.34	3.09	2.76
VDT3	2.94	3.11	2.66	2.71	2.93	3.07	3.57	2.95	2.62	2.86
VDT4	2.76	2.84	2.75	2.55	2.56	3.00	3.44	3.59	3.40	2.81

Total species richness excluding introduced species decreased within all four treatments since the 2015 monitoring (Figure 10). Overall, all four treatments were comparable, however as with the results from 2015 monitoring, treatments 3 and 4 again had the highest total native species richness with 78 and 84 species across each treatment respectively. The highest total species richness including introduced species was again recorded in treatment 4 whilst the lowest was recorded in treatment 2 (85 and 66 species respectively).



	VDT1 + I	VDT1 - I	VDT2 + I	VDT2 - I	VDT3 + I	VDT3 - I	VDT4 + I	VDT4 - I
2012	38	33	46	43	53	50	56	53
2013	63	55	67	61	77	72	77	70
2014	81	70	77	71	86	87	94	85
2015	83	76	86	80	94	86	95	89
2019	79	75	66	64	81	78	85	84

Figure 10: Species richness (total number of species) per VDT treatment during 2012, 2013, 2014, 2015 and 2019 (+I and −I: including and excluding introduced species respectively)

5.2.2. Growth Forms

The proportion of alive plants by growth form have varied throughout the survey years (2012 – 2019) (Figure 11). The proportion of perennial herbs and shrubs have shown a general increase in the 2019 survey compared to previous years, while annual grasses and annual herbs have decreased in the current survey compared to previous years. The proportion of alive sedges and rushes has remained somewhat uniform when compared to previous survey years. Furthermore, the proportion of perennial grasses has remained mostly similar to the 2015 survey, however this growth form has been mostly variable across previous survey years (2012, 2013 and 2014). In previous years annual herbs have been the dominant alive growth form occurring within the VDT trial. Conversely, in the current survey the most dominant growth form is perennial herbs in all treatments aside from treatment 3, of which the dominant growth form is shrubs (37.63 %). Treatment 4 had the highest proportion of perennial herbs (34.20 %) showing an increase since the 2015 monitoring (23.24 %). Treatment 1 had the lowest proportion of perennial herbs (23.44 %), however still showed an increase from the 2015 monitoring (17.80 %).

The proportions of dead growth forms within all treatments between 2012 and 2019 was highly variable (Figure 12). In the current survey the most dominant dead growth form is shrubs in all treatments aside from treatment 2, in which perennial herbs make up the dominant dead growth form (47.37 %), interestingly this treatment had 0.00 % dead shrubs. Growth forms making up the smallest dead proportion in the current survey were annual and perennial grasses, and annual herbs. The proportion of these growth forms is considerably less than that of the 2015 survey, for example, the dead annual herb proportion in the 2015 versus the 2019 survey was 53.66 % and 3.77 % respectively. The high variability across survey years currently does not show any major long term trends in regards to proportions of dead growth forms between 2012 and 2019.

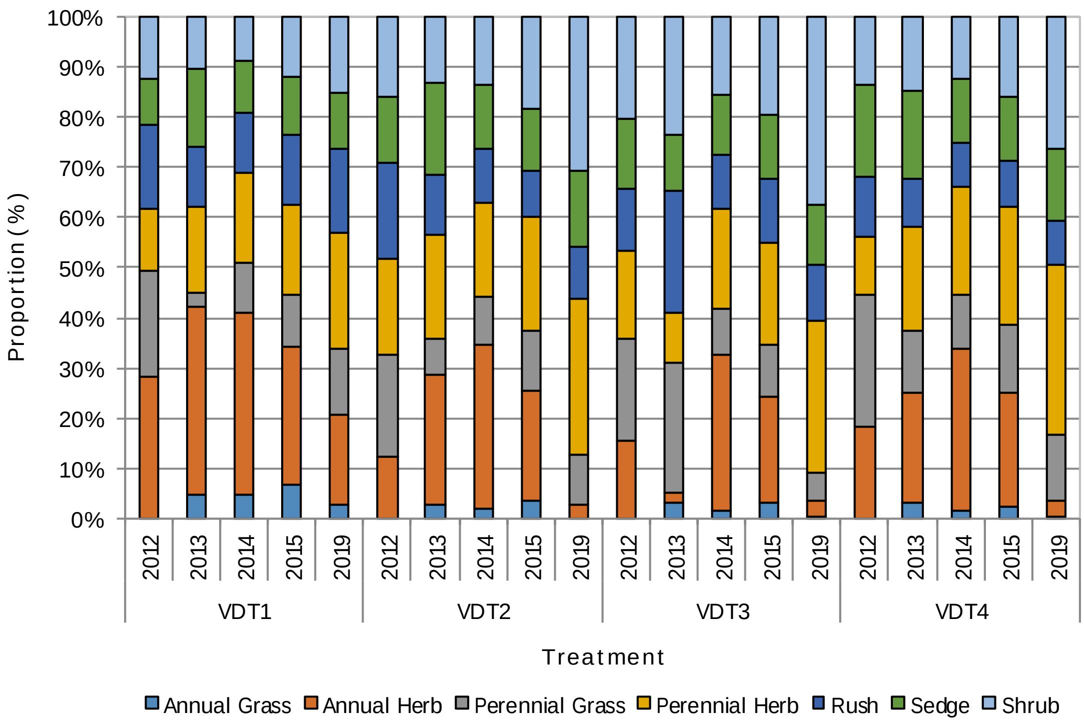


Figure 11: Proportion (%) of alive plants by growth form per VDT treatment during 2012, 2013, 2014, 2015 and 2019

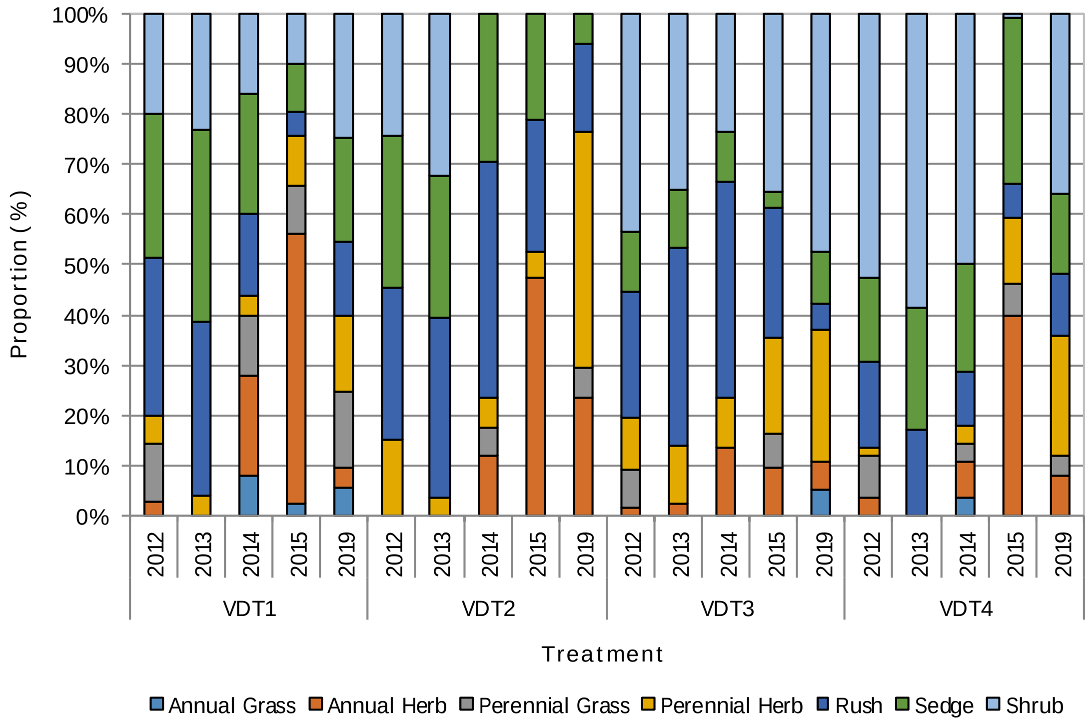


Figure 12: Proportion (%) of dead plants by growth form per VDT treatment during 2012, 2013, 2014, 2015 and 2019

5.2.3. Species Regeneration Response

Between 2012 and 2014 within all four treatments there was a noticeable increase in the proportions of alive seeder species and a reduction in the proportions of alive resprouter species (Figure 13). However, the 2015 and 2019 surveys have seen an increasing trend within all four treatments, in the proportions of alive resprouter species, with a concurrent reduction in the proportions of alive seeder species. Treatment 2 had the highest proportion of alive resprouter species in 2019 (47.69 %) and lowest proportion of alive seeder species (52.31 %), whilst treatment 1 had the lowest proportion of alive resprouter species (27.43%) and highest proportion of alive seeder species (72.57 %).

The proportion of dead resprouter species has mostly shown a decrease since the 2012 survey (Figure 14). The current 2019 survey follows this trend, aside from a slight increase in dead resprouter species in treatments 1 and 4 since the 2015 survey. Treatment 2 had the highest proportions of dead resprouter species (41.18 %), whilst treatment 3 had the highest proportion of dead seeder species (94.74 %).

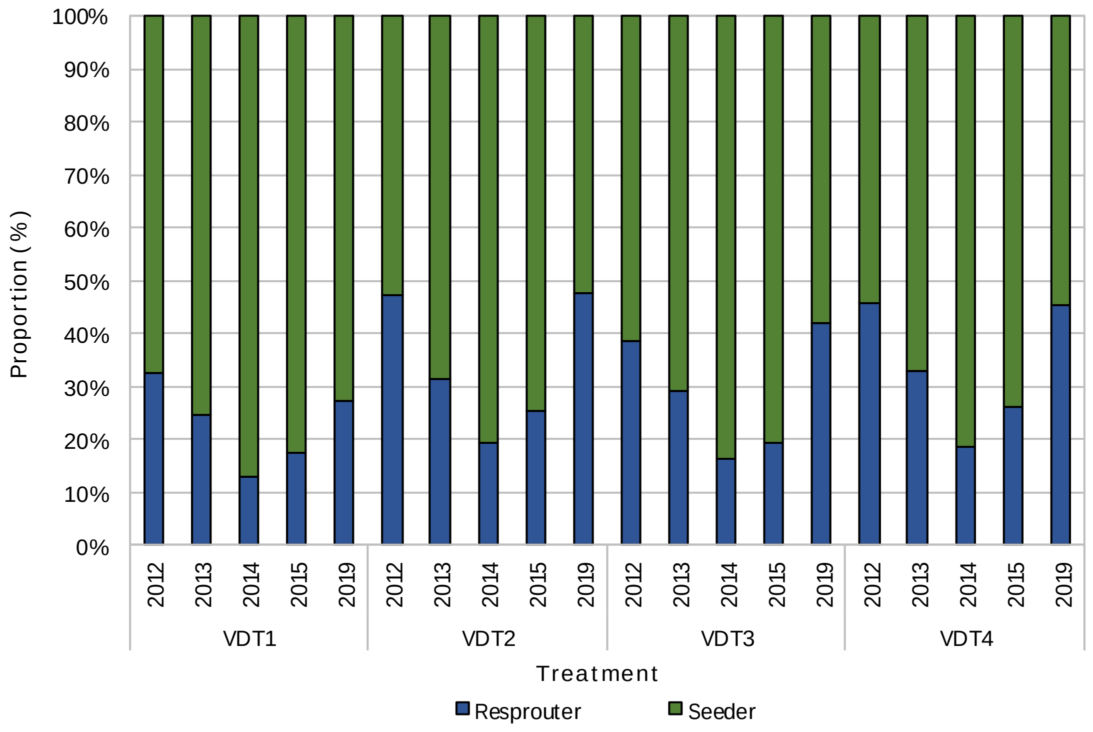


Figure 13: Proportion (%) of alive resprouter and seeder species per VDT treatment during 2012, 2013, 2014, 2015 and 2019

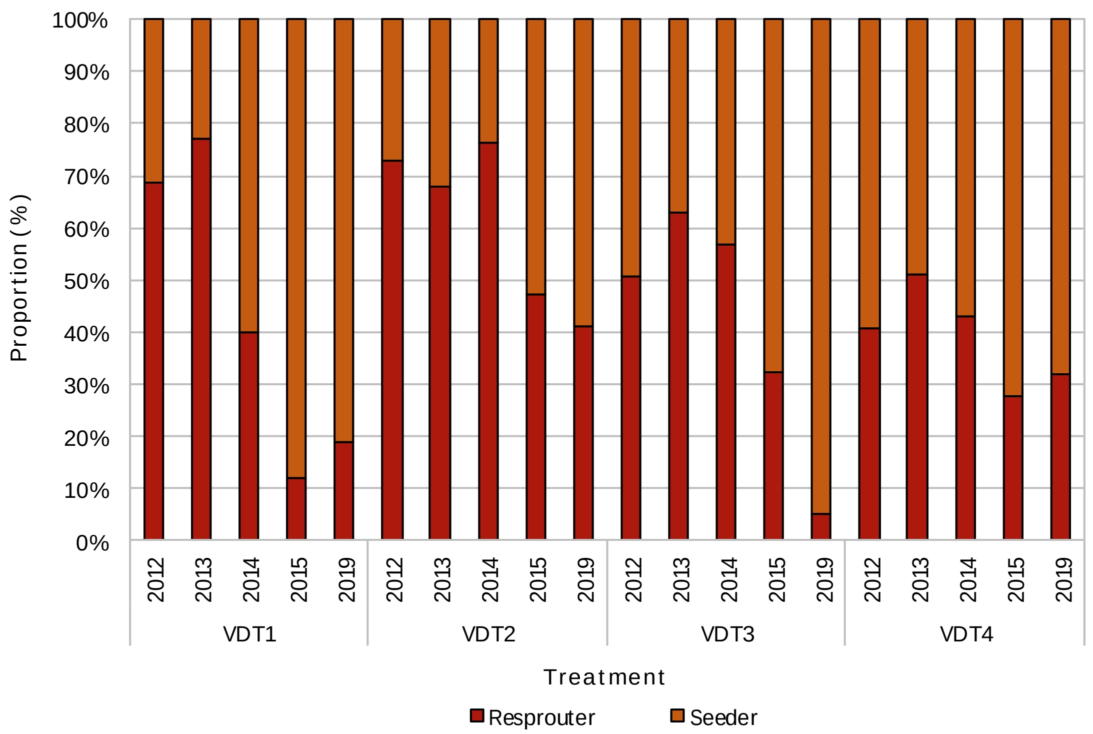


Figure 14: Proportion (%) of dead resprouter and seeder species per VDT treatment during 2012, 2013, 2014, 2015 and 2019

5.2.4. Anecdotal Observations

A few notable anecdotal observations were recorded during monitoring in 2019. There were generally high numbers of resprouting plants and additional regeneration across the majority of the trial VDT area. There was an overall increase in foliage cover, proteaceous shrubs were observed to be resprouting, and in particular, *Adenanthos cygnorum* was noticeably larger than previous monitoring years (Plate 1). The continual presence of the tuberous species such as *Haemodorum* and *Thysanotus* (Plate 2) this year (only observed for the first time in 2015 monitoring) suggests that the topsoil stored seedbank has contained these species and the depth of the translocated vegetation was deep enough to maintain these tubers underground and intact.

An increase shrub growth and soil-binding sedges and rushes has resulted in an increase in soil stabilisation, and a reduction in water and wind driven soil erosion which was observed in previous monitoring years. This has also resulted in increased leaf litter and other plant debris. As mentioned earlier an overall reduction in weed species has also been observed in the area.

Plate 1: Anecdotal observations within the VDT trial area. Increased coverage of *Adenanthos cygnorum* in 2019 (left), compared to 2015 monitoring (right) (VDT Treatment 3, Transect 4 START).

Plate 2: General anecdotal observations within the VDT trial area. *Thysanotus teretifolius*

6. DISCUSSION

6.1. Limitations

This report presents results from the fifth monitoring of the VDT trial transects since initial establishment and baseline monitoring in 2012. As a result of the relatively short duration and experimental nature of this trial, there are some limitations. The collected data has been presented in graphs that allow for comparisons between treatments, as opposed to between transects, to allow for any overall general trends to be observed. Additionally, there is a lack of "success criteria" and timeframes for achieving these criteria for the VDT trial, which makes it difficult to completely evaluate the progress of the trial other than to outline basic components such as plant density, foliage cover, species richness and extent of introduced species. However, this may be negated by the limited published research available on the use of community translocation for comparisons, combined with the baseline nature of this trial which is to primarily determine the future potential of utilising this rehabilitation technique on a larger scale at Iluka.

The handling of vegetation and soil via machinery is likely to have had a detrimental impact to some extent on the translocated vegetation. However the VDT technique has been utilised in New Zealand for the transfer of manuka-scrub for over a decade, and Ross (2008) suggested that operator skill is required to achieve a good result. Norman and Koch (2007) concluded that there is a possibility that the roots and tubers of transferred resprouters are sensitive to changes in moisture content and machinery damage. An attempt should be made to cover the majority of vegetation roots and tubers to minimise stress and water loss and to aid in nutrient uptake. Additionally, during the translocation process, the soil profile inevitably would be altered, including the disturbance of soil microbes (including mycorrhizas). Lamont (1984) stated that where clumps or individuals of the same or related species are isolated from each other, there is a risk that kwongan species with host specific mycorrhizal requirements might have a restricted distribution through the lack of fungal continuity. The VDT trial area contains genera such as *Leucopogon* which are known to have host-specific 'ericoid' mycorrhizas, whilst *Caladenia* species contain orchid mycorrhizas. However this is not an issue for species that are non-mycorrhizal or those that require general mycorrhizas (Lamont 1984).

6.2. Comparison of VDT Treatments

Five introduced species were recorded in the VDT trial this year, a decrease from the 2015 monitoring where ten introduced species were recorded. The reduction in the numbers of introduced species across the trial irrespective of treatment may be due to the increase in plant density and foliage cover across the trial area combined with a decrease in rainfall in the three months preceding the survey, which may have impeded further establishment of introduced species within these areas. Treatment 4 had the lowest incidence of introduced species (1 individual), with treatment 1 again having the highest incidence of introduced species (59 individual plants).

Mean alive plant densities decreased in VDT treatments 1 and 3 and increased in treatments 2 and 4, since the monitoring in 2015. Alive foliage has continually increased across the survey years and in the current survey has more than doubled that of the 2015 survey in every treatment. This suggests that although alive density has decreased, combined with a concurrent increase in alive foliage cover, the vegetation within the trial is beginning to recover from the stresses imposed upon it due to the different trial treatments. The larger, more dominant plants appeared to have had a flush of growth, and the increase in size (as demonstrated by increased mean alive foliage cover) may have resulted in the death of smaller, less dominant plants due to competition, and hence an increase in mean dead plant densities.

Mean alive foliage cover increased in all treatments, following the same trajectory as previous monitoring years. Treatments which were not slashed (treatments 3 and 4) have the highest mean alive foliage cover. However, overall no strong conclusions can be drawn in relation to treatments and foliage cover as treatment 2 which was slashed also had a mean alive foliage cover, almost matching that of treatment

4. It is encouraging to see a large increase in foliage cover since the last monitoring in 2015. Mean dead foliage cover recorded this year saw an overall increase in comparison to 2015 monitoring, however treatments 3 and 4 had less dead foliage cover than the survey years prior to the 2015 monitoring.

The Shannon-Weiner diversity indices (H') for density increased within all treatments between 2015 and 2019, with the exception of treatment 2 (2.40 and 2.01 respectively). The Shannon-Weiner diversity indices (H') for foliage cover showed a reduction in all treatments between 2015 and 2019, with the exception of treatment 3, which increased. The increased H' value for density indicates a positive trend for species diversity in the VDT trial. A reduced H' value for foliage cover is most likely attributable to the increased growth of dominant shrub species, in particular, *Adenanthos cygnorum*, along with other species such as *Conospermum triplinervium* and *Leptospermum oligandrum,* which have a high percentage cover compared to other species.

Total species richness excluding introduced species decreased within all four treatments since the 2015 monitoring. This is most likely due to a reduction in annual species seen in 2019 compared to 2015. A reduction in annual species in this year's survey can be attributed to reduced rainfall and increased temperatures in the three months preceding the survey. Total species richness including introduced species also decreased within all four treatments for the same reasons, along with a reduction in introduced species seen in this year's monitoring. Overall, all four treatments were similar, however treatments 3 and 4 (non-slashed treatments) again had the highest total native species richness with 78 and 84 species across each treatment respectively.

The proportion of alive plants by growth form has varied throughout the survey years (2012 – 2019). In this year's monitoring the proportion of perennial herbs and shrubs have increased compared to previous years, while annual grasses and annual herbs have decreased in the current survey compared to previous years. This difference is largely due to the decrease in density of annual herbs such as *Gnephosis tenuissima* and *Levenhookia* spp. These species were recorded last year in wetter areas between the translocated sods of vegetation, where micro-habitats have been created due to the excessive water content within the soil. As previously mentioned, the reduced rainfall this season has likely resulted in less annual species being present. The increased proportion of shrubs and perennial herbs is a result of the increased growth of shrub species previously mentioned such as *Adenanthos cygnorum* and perennial herbs such as *Conostylis* species. The proportions of dead growth forms within all treatments between 2012 and 2019 were highly variable (Figure 12). In the current survey the most dominant dead growth form is shrubs, in all treatments aside from treatment 2, in which perennial herbs make up the dominant dead growth form. This correlates with the overall increase in alive shrub growth form in the survey area. Some plant death is beneficial, according to Ross *et al*. (2000) it represents a recycling of nutrients and serves as habitat and a food source for invertebrates.

Between 2012 and 2014 within all four treatments there was a noticeable increase in the proportions of alive seeder species and a reduction in the proportions of alive resprouter species (Figure 13). However, the 2015 and 2019 surveys have seen an increasing trend within all four treatments, in the proportions of alive resprouter species, with a concurrent reduction in the proportions of alive seeder species. This is encouraging given that recalcitrant (cannot be propagated easily from seed or vegetatively) resprouter species from the families *Cyperaceae* and *Restionaceae* have often been absent in past rehabilitated areas using differing techniques to the VDT trial (Dobrowolski 2014).

The proportion of dead resprouter species has mostly shown a decrease since the 2012 survey. The current 2019 survey follows this trend, aside from a slight increase in dead resprouter species in treatments 1 and 4 since the 2015 survey. The overall decrease in dead resprouter species suggests these species are now stabilising after the stress from the initial translocation. There appears to be no significant difference between treatments and the success of resprouter species, although it may be noted that treatment 1 does have a lower proportion of resprouter species it is still following the increasing trend seen with the other treatments.

A few notable anecdotal observations were recorded during monitoring in 2019. There were generally high numbers of resprouting plants and additional regeneration across the majority of the trial VDT area. There was an overall increase in foliage cover, proteaceous and myrtaceaous shrubs were observed to be resprouting, in particular, *Adenanthos cygnorum* was noticeably larger, making up a higher percentage foliage cover than previous years. Furthermore, an increase in shrub growth and soil-binding sedges and rushes has resulted in an increase in soil stabilisation, and a reduction in water and wind driven soil erosion which was observed in previous monitoring years.

The Proteaceous species, which are a major component of kwongan heath are showing signs of regeneration. The regeneration of Proteaceous shrubs in particular appears to be somewhat slower than other plant families, this may in part be due to the damage caused to lignotuberous shrub species during translocation coupled with slow growth rates and the lack of ideal conditions for seed. One possible reason for the high level of Proteaceous deaths may be the depth of the translocated soil, which at 300 – 400 mm is most likely too shallow to allow the full translocation of the deep roots of some larger shrubs. Roots of the some of the larger shrub species occurring in the area may go as deep as 2 m, with tap roots extending beyond 2 m (Dodd *et al.* 1984). However large Proteaceous shrubs were recorded throughout the VDT area. Numerous *Conospermum triplinervium* were recorded throughout the trial as large flowering plants, suggesting that the translocated soil seedbank holds viable seeds, and that this species is regenerating via topsoil stored seed. Current observations within the VDT area do not show many *Banksia* or *Petrophile* species to be regenerating.

Overall, it is difficult to make any strong correlations between the treatments used and the success of the rehabilitation. However, it can be noted that treatment 1 (slashed with the application of Envy transpiration blocker) appears the least successful; with less foliage cover, less resprouter species, the least mean alive density of plants per square meter and contains the highest number and density of introduced species.

Overall the technique of VDT appears to have more success in the regeneration of recalcitrant and resprouting species to the receiving areas.

7. CONCLUSION AND RECOMMENDATIONS

It appears from quantitative results and anecdotal observations that there is a good level of regeneration of rush and sedge species this year, in addition to the large increase in foliage cover for shrub species.

Overall it appears that treatment 1 fared worse than the other treatments, as indicated by less foliage cover, less resprouter species, the least mean alive density of plants per square meter and the highest number and density of introduced species. As a whole, eight years since the vegetation has been translocated there appears to be little difference in the effect of treatment on the receiving vegetation. The vegetation in all of the treatments have undergone a very high level of stress, but appear to be regenerating, with significantly increased foliage cover and reduced levels of erosion observed in the current survey. However, it must be noted that some key dominant species found in undisturbed kwongan such as *Banksia* and *Petrophile* species are yet to become apparent in the vegetation structure.

In summary, it is recommended to:

- Continue to monitor the VDT transects to assess the survivorship and progress of the translocated vegetation, in particular; Proteaceae, Restionaceae and Cyperaceae species;
- Monitor the numbers and coverage of introduced species within the VDT area, and control if necessary; and
- Maintain monitoring the extent of soil compaction, drainage and erosion within the trial area, and attempt to remediate any problematic areas.

8. ACKNOWLEDGEMENTS

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9. PERSONNEL

The following Mattiske Consulting Pty Ltd personnel were involved in this project:

NAME	POSITION	PROJECT INVOLVEMENT	FLORA COLLECTION PERMITS
Dr E.M. Mattiske	Managing Director & Principal Ecologist	Planning, managing, reporting	N/A
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Dr F. Riviera	Senior Botanist	Fieldwork	FB62000027
Ms J. Rogers	Botanist	Fieldwork, data analysis	FB62000032
Ms L. Taaffe	Botanist	Fieldwork, reporting	FB62000021
Mr B. Ellery	Taxonomist	Plant identification	N/A

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FloraBase ¬– the Western Australian Flora, Department of Parks and Wildlife. Viewed November 2019 <https://florabase.dpaw.wa.gov.au.>

APPENDIX A1: THREATENED AND PRIORITY FLORA DEFINITIONS

Under section 179 of the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), threatened flora are categorised as extinct, extinct in the wild, critically endangered, endangered, vulnerable and conservation dependent (Table A1.1).

Table A1.1 Federal definition of threatened flora species

Note: Adapted from section 179 of the EPBC Act.

CODE	CATEGORY	DEFINITION
Ex	Extinct	Species which at a particular time if, at that time, there is no reasonable doubt that the last member of the species has died.
ExW	Extinct in the Wild	Species which is known only to survive in cultivation, in captivity or as a naturalised population well outside its past range; or it has not been recorded in its known and/or expected habitat, at appropriate seasons, anywhere in its past range, despite exhaustive surveys over a time frame appropriate to its life cycle and form.
CE	Critically Endangered	Species which at a particular time if, at that time, it is facing an extremely high risk of extinction in the wild in the immediate future, as determined in accordance with the prescribed criteria.
E	Endangered	Species which is not critically endangered and it is facing a very high risk of extinction in the wild in the immediate or near future, as determined in accordance with the prescribed criteria.
V	Vulnerable	Species which is not critically endangered or endangered and is facing a high risk of extinction in the wild in the medium-term future, as determined in accordance with the prescribed criteria.
CD	Conservation Dependent	Species which at a particular time if, at that time, the species is the focus of a specific conservation program, the cessation of which would result in the species becoming vulnerable, endangered or critically endangered within a period of 5 years.

The *Biodiversity Conservation Act 2016* (BC Act) provides for (amongst other things) the protection of flora that is facing an extremely high risk of extinction in the wild in the immediate, near or medium-term future in Western Australia under Part 10 (Division 2).

Threatened flora are listed in the *Wildlife Conservation (Rare Flora) Notice 2018* (under Part 2, Division 1, Subdivision 2 of the BC Act; Department of Biodiversity, Conservation and Attractions ([DBCA] 2018a) and are categorised under Schedules 1-3. A flora species is defined as threatened if it is facing an extremely high risk of extinction in the wild in the immediate, near or medium-term future, pursuant to sections 20, 21 and 22 of the BC Act (DBCA 2019a). Threatened species are categorised as critically endangered, endangered, and vulnerable (Table A1.2).

Table A1.2 State definition of threatened flora species

Note: Adapted from DBCA (2019a).

CODE	CATEGORY	DEFINITION
CR	Critically endangered	Species considered to be facing an extremely high risk of becoming extinct in the wild (listed under Schedule 1 of the *Wildlife Conservation (Rare Flora) Notice 2018*).
EN	Endangered	Species considered to be facing a very high risk of becoming extinct in the wild (listed under Schedule 2 of the *Wildlife Conservation (Rare Flora) Notice 2018*).
VU	Vulnerable	Species considered to be facing a high risk of becoming extinct in the wild (listed under Schedule 3 of the *Wildlife Conservation (Rare Flora) Notice 2018*).

Priority flora species are defined as "possibly threatened species that do not meet the survey criteria, or are otherwise data deficient" or species that are "adequately known, are rare but not threatened, meet criteria for near threatened or have recently been removed from the threatened species list" for other than taxonomic reasons" (DBCA 2019a). Priority species are not afforded any additional protection under state or federal legislation, however are considered significant under the Environmental Protection Authority's *Environmental Factor Guideline: Flora and Vegetation* (Environmental Protection Authority 2016b). The DBCA categorises priority flora into four categories: Priority 1; Priority 2, Priority 3 and Priority 4 (Table A1.3).

Table A1.3: State definition of priority flora species

Note: Adapted from DBCA (2019a).

CODE	CATEGORY	DEFINITION
P1	Priority 1: Poorly-known species	Known from one or a few locations (< 5) which are potentially at risk. All occurrences are either: very small; or on lands not managed for conservation; or are otherwise under threat of habitat destruction or degradation. In urgent need of further survey.
P2	Priority 2: Poorly-known species	Known from one or a few locations (< 5). Some occurrences are on lands managed primarily for nature conservation. In urgent need of further survey.
P3	Priority 3: Poorly-known species	Known from several locations and the species does not appear to be under imminent threat; or from few but widespread locations with either a large population size or significant remaining areas of apparently suitable habitat, much of it not under imminent threat. In need of further survey.
P4	Priority 4: Rare, Near Threatened, and other species in need of monitoring	a) Rare - Species that are considered to have been adequately surveyed, or for which sufficient knowledge is available, and that are considered not currently threatened or in need of special protection, but could be if present circumstances change. These species are usually represented on conservation lands. b) Near Threatened - Species that are considered to have been adequately surveyed and that do not qualify for Conservation Dependent, but that are close to qualifying for Vulnerable. c) Other - Species that have been removed from the list of threatened species during the past five years for reasons other than taxonomy.

APPENDIX A2: CATEGORIES AND CONTROL MEASURES OF DECLARED PEST (PLANT) ORGANISMS IN WESTERN AUSTRALIA

Section 22 of Western Australia's *Biosecurity and Agriculture Management Act 2007* (BAM Act) makes provision for a plant taxon to be listed as a declared pest organism in respect to parts of, or the entire State. According to the BAM Act, a declared pest is defined as a prohibited organism (section 12), or an organism for which a declaration under section 22 (2) of the Act is in force.

Under the *Biosecurity and Agriculture Management Regulations 2013* (WA), declared pest plants are placed in one of three control categories, C1 (exclusion), C2 (eradication) or C3 (management), which determines the measures of control which apply to the declared pest (Table A4.1). The current listing of declared pest organisms and their control category is through the Western Australian Organism List (Department of Primary Industries and Regional Development 2019).

Table A3.1 Categories and control measures of declared pest (plant) organisms

Note: Adapted from *Biosecurity and Agriculture Management Regulations 2013*.

CONTROL CATEGORY	CONTROL MEASURES
C1 (Exclusion) '(a) Category 1 (C1) — Exclusion: if in the opinion of the Minister introduction of the declared pest into an area or part of an area for which it is declared should be prevented.' Pests will be assigned to this category if they are not established in Western Australia and control measures are to be taken, including border checks, in order to prevent them entering and establishing in the State.	In relation to a category 1 declared pest, the owner or occupier of land in an area for which an organism is a declared pest or a person who is conducting an activity on the land must take such of the control measures specified in subregulation (1) as are reasonable and necessary to destroy, prevent or eradicate the declared pest.
C2 (Eradication) '(b) Category 2 (C2) — Eradication: if in the opinion of the Minister eradication of the declared pest from an area or part of an area for which it is declared is feasible.' Pests will be assigned to this category if they are present in Western Australia in low enough numbers or in sufficiently limited areas that their eradication is still a possibility.	In relation to a category 2 declared pest, the owner or occupier of land in an area for which an organism is a declared pest or a person who is conducting an activity on the land must take such of the control measures specified in subregulation (1) as are reasonable and necessary to destroy, prevent or eradicate the declared pest.
C3 (Management) '(c) Category 3 (C3) — Management: if in the opinion of the Minister eradication of the declared pest from an area or part of an area for which it is declared is not feasible but that it is necessary to: (i) alleviate the harmful impact of the declared pest in the area; or (ii) reduce the number or distribution of the declared pest in the area; or (iii) prevent or contain the spread of the declared pest in the area.' Pests will be assigned to this category if they are established in Western Australia but it is feasible, or desirable, to manage them in order to limit their damage. Control measures can prevent a C3 pest from increasing in population size or density or moving from an area in which it is established into an area which currently is free of that pest.	In relation to a category 3 declared pest, the owner or occupier of land in an area for which an organism is a declared pest or a person who is conducting an activity on the land must take such of the control measures specified in subregulation (1) as are reasonable and necessary to: (a) alleviate the harmful impact of the declared pest in the area for which it is declared; or (b) reduce the number or distribution of the declared pest in the area for which it is declared; or (c) prevent or contain the spread of the declared pest in the area for which it is declared.

APPENDIX A3: OTHER DEFINITIONS

Environmentally sensitive areas

Environmentally sensitive areas are declared by the State Minister under section 51B of the *Environmental Protection Act 1986* (EP Act) and are listed in the *Environmental Protection (Environmentally Sensitive Areas) Notice 2005*, gazetted 8 April 2005. Specific environmentally sensitive areas relevant to this report include: a defined wetland and the area within 50 metres of the wetland; the area covered by vegetation within 50 metres of rare flora; the area covered by a threatened ecological community – further areas and information are described in the *Environmental Protection (Environmentally Sensitive Areas) Notice 2005*.

Conservation significant flora

Under the *Environmental Factor Guideline: Flora and Vegetation* (Environmental Protection Authority 2016b), flora may be considered significant for a range of reasons, including, but not limited to the following:

- being identified as threatened or priority species;
- locally endemic or associated with a restricted habitat type (e.g. surface water or groundwater dependent ecosystems);
- new species or anomalous features that indicate a potential new species;
- representative of the range of a species (particularly, at the extremes of range, recently discovered range extensions, or isolated outliers of the main range);
- unusual species, including restricted subspecies, varieties or naturally occurring hybrids; or
- relictual status, being representative of taxonomic groups that no longer occur widely in the broader landscape.

Conservation significant vegetation

Under the *Environmental Factor Guideline: Flora and Vegetation* (Environmental Protection Authority 2016b), vegetation may be considered significant for a range of reasons, including, but not limited to the following:

- being identified as threatened or priority ecological communities;
- restricted distribution;
- degree of historical impact from threatening processes;
- a role as a refuge; or
- providing an important function required to maintain ecological integrity of a significant ecosystem.

APPENDIX B : VASCULAR PLANT SPECIES RECORDED IN THE VEGETATION DIRECT TRANSFER TRIAL AREA, 2012 to 2019

Note: * denotes introduced species; P1-P4 denote priority flora species (WAH 1998-)

FAMILY	Species	2012	2013	2014	2015	2019
AMARANTHACEAE	*Ptilotus polystachyus*	x	x	x	x	
	Lyginia barbata	x	x	x	x	x
	Lyginia imberbis	x	x		x	x
	Lyginia sp.			x	x	x
ARALIACEAE	*Trachymene pilosa*	x	x	x	x	x
ASPARAGACEAE	?*Acanthocarpus* sp.			x		
	Lomandra hastilis		x	x	x	x
	Lomandra sp.				x	x
	Thysanotus multiflorus			x		
	Thysanotus spiniger					x
	Thysanotus teretifolius				x	x
	Thysanotus triandrus				x	x
	Thysanotus sp.			x	x	x
ASTERACEAE	* *Arctotheca calendula*	x	x	x	x	x
	Blennospora drummondii			x		
	Gnephosis drummondii			x		
	Gnephosis tenuissima	x	x	x	x	x
	Hyalosperma demissum		x	x	x	
	* *Hypochaeris glabra*	x	x	x	x	x
	Podotheca angustifolia			x	x	
	Podotheca gnaphalioides		x	x	x	
	Quinetia urvillei		x			
	* *Sonchus oleraceus*		x	x	x	
	* *Ursinia anthemoides* subsp. *anthemoides*	x	x	x	x	x
	Asteraceae sp.			x		
CAMPANULACEAE	*Isotoma hypocrateriformis*			x		
	* *Wahlenbergia capensis*	x	x	x	x	x
	Wahlenbergia preissii			x	x	
CASUARINACEAE	*Allocasuarina humilis*	x	x	x	x	x
	Allocasuarina microstachya	x				
	Allocasuarina sp.				x	
CELASTRACEAE	*Stackhousia* ?*dielsii*					x
	Tripterococcus brunonis			x	x	x
CENTROLEPIDACEAE	*Aphelia nutans*			x		
	Centrolepis aristata	x	x	x	x	x
	Centrolepis pilosa	x	x	x	x	x
	Centrolepis polygyna		x	x	x	x
	Centrolepis sp.		x	x	x	
COLCHICACEAE	*Burchardia congesta*	x	x	x	x	x
CRASSULACEAE	*Crassula colorata*		x	x	x	
	Crassula sp.			x		

APPENDIX B : VASCULAR PLANT SPECIES RECORDED IN THE VEGETATION DIRECT TRANSFER TRIAL AREA, 2012 to 2019

Note: * denotes introduced species; P1-P4 denote priority flora species (WAH 1998-)

FAMILY	Species	2012	2013	2014	2015	2019
CYPERACEAE	*Caustis dioica*	x	x	x	x	x
	* *Cyperus tenellus*			x		
	Isolepis congrua	x				
	Isolepis marginata				x	x
	Lepidosperma aff *apricola*		x	x	x	x
	Lepidosperma leptostachyum				x	
	Lepidosperma scabrum sens. Lat.					x
	Lepidosperma tenue	x				
	Lepidosperma sp.	x				
	Mesomelaena pseudostygia	x	x	x	x	x
	Mesomelaena tetragona	x	x	x	x	x
	Schoenus brevisetis		x	x	x	x
	Schoenus clandestinus					x
	Schoenus curvifolius	x	x	x	x	x
	Schoenus griffinianus (P3)			x	x	x
	Schoenus insolitus	x	x	x	x	x
	Schoenus ?latitans			x	x	x
	Schoenus nanus		x	x	x	x
	Schoenus pedicellatus	x	x	x	x	x
	Schoenus pleiostemoneus	x	x	x	x	x
	Schoenus rigens			x	x	x
	Schoenus sp. A3 Ciliate Sheaths (K.R. Newbey 9402)			x		
	Schoenus sp.	x	x	x	x	x
	Cyperaceae sp.		x	x	x	
DILLENIACEAE	*Hibbertia aurea*	x	x	x		x
	Hibbertia acerosa					x
	Hibbertia crassifolia	x	x	x	x	x
	Hibbertia hypericoides subsp. *hypericoides*	x	x	x	x	x
	Hibbertia hypericoides subsp. *septentrionalis*	x	x	x	x	
	Hibbertia robur				x	x
	Hibbertia sp.		x			x
DROSERACEAE	*Drosera eneabba*	x	x	x	x	x
	Drosera thysanosepala		x	x		
	Drosera paleacea	x	x	x		
	Drosera stolonifera	x	x	x	x	
	Drosera sp.		x	x	x	
ECDEIOCOLEACEAE	*Ecdeiocolea monostachya*	x	x	x	x	x
ERICACEAE	*Andersonia heterophylla*					x
	Andersonia sp.				x	
	Astroloma glaucescens				x	x
	Astroloma sp.			x	x	
	Leucopogon polymorphus	x				
	Leucopogon prolatus		x	x	x	x
	Leucopogon sp.	x	x			x
	Lysinema pentapetalum					x
	Styphelia stomarrhena	x	x	x		
	Styphelia xerophylla			x	x	x
	Ericaceae sp.		x	x	x	

APPENDIX B : VASCULAR PLANT SPECIES RECORDED IN THE VEGETATION DIRECT TRANSFER TRIAL AREA, 2012 to 2019

Note: * denotes introduced species; P1-P4 denote priority flora species (WAH 1998-)

FAMILY		Species	2012	2013	2014	2015	2019
EUPHORBIACEAE		*Monotaxis bracteata*				x	
		Monotaxis grandiflora var. *grandiflora*		x	x	x	x
		Monotaxis sp.			x		x
FABACEAE		*Acacia auronitens*				x	x
		Acacia barbinervis subsp. *borealis*	x	x	x	x	x
		Acacia lasiocarpa		x	x	x	x
		Acacia pulchella	x	x	x	x	x
		Acacia sp.				x	x
		Davesia incrassata subsp. *teres*					x
		Daviesia nudiflora	x	x			
		Daviesia nudiflora subsp. *nudiflora*	x	x	x	x	
		Daviesia pedunculata					x
		Daviesia podophylla				x	x
		Daviesia sp.		x			
		Jacksonia floribunda	x	x	x	x	x
		Jacksonia ?*hakeoides*	x	x	x	x	x
		Jacksonia lehmannii	x	x	x		x
		Jacksonia ramulosa			x	x	
		Jacksonia restioides		x	x	x	x
		Jacksonia sp.		x	x		
	*	*Ornithopus compressus*				x	
	*	*Trifolium arvense* var. *arvense*		x	x		
	*	*Trifolium* sp.			x		
		Fabaceae sp.			x		
GOODENIACEAE		*Dampiera carinata*				x	x
		Dampiera sp.		x		x	x
		Lechenaultia biloba			x	x	
		Lechenaultia floribunda				x	x
		Scaevola ?*canescens*				x	
		Goodeniaceae sp.		x	x		
HAEMODORACEAE		*Anigozanthos humilis*		x	x	x	x
		Anigozanthos sp.		x	x	x	x
		Conostylis aculeata	x	x	x	x	x
		Conostylis aurea			x	x	x
		Conostylis canteriata				x	x
		Conostylis crassinerva	x	x	x	x	x
		Conostylis crassinerva subsp. absens					x
		Conostylis dielsii subsp. *dielsii*	x	x	x		
		Conostylis neocymosa	x			x	x
		Conostylis tomentosa				x	x
		Conostylis sp.	x	x	x	x	
		Macropidia fuliginosa					x
		Haemodoraceae sp.			x	x	
HEMEROCALLIDACEAE		*Johnsonia pubescens* subsp. *pubescens*	x	x	x	x	x
		Johnsonia sp.			x		
IRIDACEAE	*	*Romulea rosea*		x	x		
LAMIACEAE		*Hemiandra* sp. Eneabba (H. Demarz 3687) (P3)					x

APPENDIX B : VASCULAR PLANT SPECIES RECORDED IN THE VEGETATION DIRECT TRANSFER TRIAL AREA, 2012 to 2019

Note: * denotes introduced species; P1-P4 denote priority flora species (WAH 1998-)

FAMILY		Species	2012	2013	2014	2015	2019
LAURACEAE		*Cassytha flava*				x	x
		Cassytha sp.			x		
LENTIBULARIACEAE		*Utricularia tenella*				x	
MYRTACEAE		*Beaufortia elegans*	x				x
		Beufortia sp.					x
		Calytrix sp.					x
		Darwinia neildiana	x			x	x
		Darwinia sanguinea	x	x	x	x	x
		Hypocalymma garderi (P3)					x
		Hypocalymma hirsutum	x	x	x		
		Hypocalymma sp.				x	
		Leptospermum oligandrum	x	x	x	x	x
		Leptospermum sp.					x
		Melalueca leuropoma					x
		Melaleuca sp.	x		x	x	
		Pileanthus filifolius	x				
		Scholtzia laxiflora	x	x	x	x	x
		Scholtzia sp.	x	x	x	x	x
		Verticordia densiflora	x	x	x	x	x
		Verticordia grandis			x		
		Verticordia ovalifolia				x	x
		Verticordia ?pennigera				x	x
		Verticordia sp.		x	x	x	
		Myrtaceae sp.	x	x	x	x	x
ORCHIDACEAE		*Caladenia* sp.			x	x	
		Microtis media subsp. *media*	x		x	x	x
		Pterostylis sp.		x	x		
		Orchidaceae sp.	x	x	x	x	x
PHYLLANTHACEAE		*Poranthera microphylla*		x	x		
POACEAE	*	*Aira caryophyllea*		x	x		
		Amphipogon turbinatus		x	x	x	x
		Aristida holathera		x	x	x	x
		Aristida sp.				x	
		Austrostipa elegantissima	x	x	x	x	
		Austrostipa hemipogon		x	x		
		Austrostipa macalpinei			x	x	x
		Austrostipa scabra			x		
		Austrostipa variabilis				x	
		Austrostipa sp.	x	x	x	x	x
	*	*Ehrharta calycina*	x	x	x	x	x
	*	*Ehrharta* sp.		x			
		Neurachne alopecuroidea	x	x	x	x	x
	*	*Pentameris airoides* subsp. *airoides*				x	
		Rytidosperma acerosum				x	
		Rytidosperma caespitosum		x	x		x
		Rytidosperma setaceum	x				
	*	*Vulpia myuros*			x	x	
		Poaceae sp.	x	x	x	x	x

APPENDIX B : VASCULAR PLANT SPECIES RECORDED IN THE VEGETATION DIRECT TRANSFER TRIAL AREA, 2012 to 2019

Note: * denotes introduced species; P1-P4 denote priority flora species (WAH 1998-)

FAMILY	Species	2012	2013	2014	2015	2019
POLYGALACEAE	*Comesperma calymega*		x		x	x
	Comesperma rhadinocarpum (P2)		x			x
	Comesperma ?rhadinocarpum (P2)			x	x	x
	Comesperma sp.		x	x	x	
	?*Comesperma* sp.					x
PORTULACACEAE	*Calandrinia corrigioloides*		x	x	x	
	Calandrinia sp.			x	x	
PRIMULACEAE	* *Lysimachia arvensis*			x		
PROTEACEAE	*Adenanthos cygnorum* subsp. *cygnorum*	x	x	x	x	x
	Banksia nivea subsp. *nivea*	x	x	x	x	x
	Banksia shuttleworthiana	x	x	x	x	x
	Conospermum triplinervium	x	x	x	x	x
	Conospermum sp.			x		
	Hakea conchifolia			x	x	
	Hakea gilbertii	x	x			
	Hakea smilacifolia					x
	Hakea trifurcata	x	x	x	x	x
	Isopogon tridens		x	x	x	x
	Lambertia multiflora var. *multiflora*	x	x	x	x	x
	Petrophile brevifolia	x	x	x	x	x
	Petrophile macrostachya	x	x	x	x	
	Petrophile scabriuscula	x	x	x	x	x
	Synaphea spinulosa subsp. spinulosa	x	x	x	x	
	Proteaceae sp.	x				
RESTIONACEAE	*Alexgeorgea nitens*			x		
	Chordifex sinuosus	x	x	x	x	x
	Desmocladus elongatus (P4)	x	x	x	x	x
	Desmocladus parthenicus	x	x	x	x	x
	Desmocladus sp.			x	x	x
	Restionaceae sp.		x			
RHAMNACEAE	*Stenanthemum humile*		x		x	
RUTACEAE	*Boronia* sp.			x		
SCROPHULARIACEAE	* *Zaluzianskya divaricata*				x	
STYLIDIACEAE	*Levenhookia pusilla*	x	x	x	x	x
	Levenhookia stipitata	x		x	x	x
	Levenhookia sp.		x			
	Stylidium crossocephalum	x	x	x	x	
	Stylidium repens	x	x	x	x	x
	Stylidium sp.		x			x

APPENDIX C: VASCULAR PLANT SPECIES RECORDED BY TREATMENT AND TRANSECT IN THE VEGETATION DIRECT TRANSFER TRIAL, 2019

Note: * denotes introduced species; P1 - P4 denote priority flora species (WAH 1998-)

Species	Treatment 1				Treatment 2				Treatment 3				Treatment 4			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Acacia auronitens						x										
Acacia barbinervis subsp. *borealis*					x		x							x	x	
Acacia lasiocarpa															x	x
Acacia pulchella			x	x				x			x				x	x
Acacia sp.																x
Adenanthos cygnorum subsp. *cygnorum*	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Allocasuarina humilis								x	x			x				
Amphipogon turbinatus				x					x							
Andersonia heterophylla		x	x								x				x	x
Anigozanthos humilis			x	x	x		x	x				x			x	x
Angiozanthos sp.										x						
Arctotheca calendula	x										x					
Aristida holathera	x		x		x				x				x			
Astroloma glaucescens					x											
Austrostipa macalpinei	x															
Austrostipa sp.																x
Banksia nivea subsp. *nivea*				x												
Banksia shuttleworthiana	x															
Beaufortia elegans																x
Beaufortia sp.																x
Burchardia congesta	x		x	x		x	x	x				x				
Calandrinia corrigioloides	x				x											
Calytrix sp.							x									
Cassytha flava					x											
Caustis dioica	x	x		x	x	x	x	x	x			x	x		x	x
Centrolepis aristata	x			x	x				x							
Centrolepis pilosa	x				x				x		x	x	x			
Centrolepis polygyna	x			x	x				x		x					
Chordifex sinuosus		x	x	x	x	x	x	x		x	x		x	x		x
Comesperma calymega		x	x	x	x	x		x	x	x	x	x			x	
Comesperma rhadinocarpum (P2)				x	x					x						
Conospermum triplinervium		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Comesperma sp.		x	x	x	x	x	x	x	x		x		x	x	x	x
Conostylis aculeata							x								x	x
Conostylis aurea				x					x	x				x		

APPENDIX C: VASCULAR PLANT SPECIES RECORDED BY TREATMENT AND TRANSECT IN THE VEGETATION DIRECT TRANSFER TRIAL, 2019

Note: * denotes introduced species; P1 - P4 denote priority flora species (WAH 1998-)

Species	Treatment 1				Treatment 2				Treatment 3				Treatment 4			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Conostylis canteriata			x	x				x		x					x	x
Conostylis crassinerva	x	x	x	x	x	x	x	x	x	x		x	x	x	x	x
Conostylis crassinerva subsp. *absens*			x	x				x	x	x	x			x	x	
Conostylis neocymosa		x		x	x	x	x	x	x	x	x	x		x	x	
Conostylis tomentosa	x	x			x	x		x	x	x	x	x	x	x	x	x
Conostylis sp.	x	x	x	x	x		x	x		x	x			x		x
Dampiera carinata			x													
Dampiera sp.				x												x
Darwinia neildiana		x								x			x			x
Darwinia sanguinea				x												
Davesia podophylla								x				x				x
Daviesia incrassata subsp. *teres*															x	
Daviesia pedunculata			x													
Desmocladus elongatus (P4)		x	x	x		x	x		x	x				x	x	x
Desmocladus parthenicus											x				x	x
Desmocladus sp.															x	x
Drosera eneabba	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Ecdeiocolea monostachya			x	x	x		x				x					
Ehrharta calycina	x												x			
Eriacaeae sp.									x							
Gnephosis tenuissima	x		x	x	x	x			x		x	x	x	x		
Hakea smilacifolia			x													
Hakea trifurcata		x					x				x			x		
Hemiandra sp. Eneabba (H. Demarz 3687) (P3)			x													
Hibbertia acerosa																x
Hibbertia aurea											x				x	
Hibbertia crassifolia								x		x						x
Hibbertia hypericoides subsp. *hypericoides*		x	x	x	x	x	x	x	x	x		x		x	x	
Hibbertia robur						x										
Hibbertia sp.																x
Hypocalymma gardneri (P3)						x								x		
Hypochaeris glabra	x		x	x	x		x		x	x			x	x		
Isolepis marginata													x			
Isopogon tridens					x					x						
Jacksonia floribunda						x	x		x							

APPENDIX C: VASCULAR PLANT SPECIES RECORDED BY TREATMENT AND TRANSECT IN THE VEGETATION DIRECT TRANSFER TRIAL, 2019

Note: * denotes introduced species; P1 - P4 denote priority flora species (WAH 1998-)

Species	Treatment 1				Treatment 2				Treatment 3				Treatment 4			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Jacksonia hakeoides												x			x	
Jacksonia lehmannii							x									
Jacksonia restioides	x													x		x
Johnsonia pubescens subsp. *pubescens*								x							x	
Lambertia multiflora var. *multiflora*			x	x	x		x	x			x				x	x
Lechenaultia floribunda					x			x	x			x			x	
Lepidosperma aff. apricola		x						x			x					
Lepidosperma scabrum sens. lat.													x		x	
Leptospermum oligandrum	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Leptospermum sp.									x							
Leucopogon prolatus	x														x	
Leucopogon sp.		x														
Levenhookia pusilla	x	x	x	x	x				x	x		x	x			
Levenhookia stipitata				x	x			x			x					x
Lomandra hastilis				x												
Lomandra sp.								x								
Lyginia barbata	x	x	x	x	x		x	x	x	x	x		x		x	
Lyginia imberbis	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Lygnia sp.										x						
Lysinema pentapetalum			x													
Macropidia fuliginosa		x														
Melaleuca leuropoma											x					
Mesomelaena pseudostygia	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Mesomelaena tetragona	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x
Microtis media					x				x		x					
Monotaxis grandiflora var. *grandiflora*				x		x			x	x	x	x	x		x	
Monotaxis sp.				x												
Myrtaceae sp.		x						x								
Neurachne alopecuroidea	x	x	x	x	x	x		x	x	x		x	x	x	x	x
Orchidaceae sp.							x							x		
Petrophile brevifolia	x															
Petrophile scabriuscula				x												
Poaceae sp.	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x
Rytidosperma caespitosum	x	x	x	x	x	x			x	x	x	x	x	x		x
Schoenus brevisetis		x	x	x	x	x										

APPENDIX C: VASCULAR PLANT SPECIES RECORDED BY TREATMENT AND TRANSECT IN THE VEGETATION DIRECT TRANSFER TRIAL, 2019

Note: * denotes introduced species; P1 - P4 denote priority flora species (WAH 1998-)

Species	Treatment 1				Treatment 2				Treatment 3				Treatment 4			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Schoenus clandestinus		x	x	x	x	x	x		x	x				x	x	
Schoenus curvifolius										x				x		
Schoenus griffinianus (P4)		x				x		x		x			x			x
Schoenus insolitus			x		x			x			x	x			x	
Schoenus ?*latitans*										x						x
Schoenus nanus	x		x	x	x				x		x		x			x
Schoenus pedicellatus		x		x	x	x		x		x						x
Schoenus pleiostemoneus																x
Schoenus rigens		x	x		x		x	x	x	x	x		x		x	x
Schoenus sp.									x				x		x	x
Scholtzia laxiflora		x	x	x		x	x		x	x	x	x	x	x	x	x
Scholtzia sp.															x	
Stackhousia ?*dielsii*						x					x					
Stylidium repens				x						x						x
Stylidium sp.			x													
Styphelia xerophylla	x	x	x	x	x	x	x	x		x	x	x		x	x	x
Thysanotus spiniger									x							
Thysanotus teretifolius		x		x	x	x				x		x	x		x	
Thysanotus triandrus							x									
Thysanotus sp.					x				x							
Trachymene pilosa	x				x		x	x	x		x		x	x	x	
Tripterococcus brunonis		x			x					x						
Ursinia anthemoides subsp. *anthemoides*	x		x		x						x		x			
Verticordia ?*pennigera*									x							
Verticordia densiflora var. *densiflora*		x	x			x	x	x	x	x	x	x			x	x
Verticordia ovalifolia								x								
Verticordia sp.								x				x	x			
Wahlenbergia capensis	x													x		
Daviesia podophylla						x										
Trachymene pilosa	x	xx	x	xx	xx	xx	x	x	x	x	x	x	x	x	x	x
Tripterococcus brunonis	x	x			x	x		x				x				
* *Ursinia anthemoides* subsp. *anthemoides*	x	x	x	x				x	x	x	x		x	x	x	x
Utricularia tenella													x			
Verticordia densiflora					x	x				x	x	x		x	x	x
Verticordia ovalifolia														x		

APPENDIX C: VASCULAR PLANT SPECIES RECORDED BY TREATMENT AND TRANSECT IN THE VEGETATION DIRECT TRANSFER TRIAL, 2019

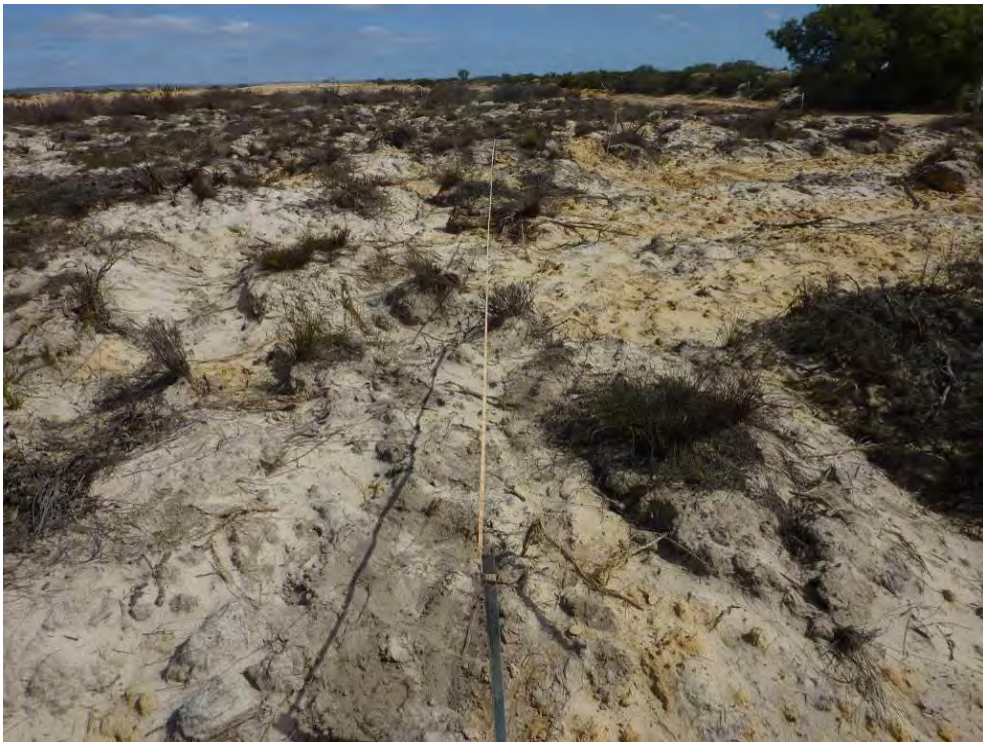
Note: * denotes introduced species; P1 - P4 denote priority flora species (WAH 1998-)

Species	Treatment 1				Treatment 2				Treatment 3				Treatment 4			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Verticordia ?*pennigera*			x													
Verticordia sp.		x		x			x	x			x					x
**Vulpia myuros* forma *myuros*	x	x	x						x							
**Wahlenbergia capensis*	x		x	x	x	x		x	x				x			
Wahlenbergia preissii		x														
**Zaluzianskya divaricata*									x				x			

APPENDIX D: SUMMARY OF INTRODUCED SPECIES RECORDED PER TRANSECT IN THE VEGETATION DIRECT TRANSFER TRIAL, 2019

Note: [1] DPAW - Department of Parks and Wildlife 2014 Midwest impact and invasiveness ratings; [2] WAOL - Western Australian Organism List (BAM Act 2007; Department of Primary Industries and Regional Development 2019); Ecological Impact Rating: L - Low; M - Medium; H - High; U - Unknown. Invasiveness Rating: S - Slow; M - Moderate; R - Rapid; U - Unknown.

Introduced Species	DPAW[1]		WAOL[2]	Individual Species Counts															
	Ecological Impact Rating	Invasiveness Rating		VDT 1				VDT 2				VDT 3				VDT 4			
				1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
**Arctotheca calendula*	*H*	R	Permitted (s11)	2	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-
**Ehrharta calycina*	*H*	R	Permitted (s11)	2	-	-	5	-	-	-	-	-	-	-	-	-	-	-	-
**Hypochaeris glabra*	*L*	R	Permitted (s11)	26	4	3	4	-	-	1	3	2	1	-	-	1	-	-	-
**Ursinia anthemoides* subsp. *anthemoides*	*H*	R	Permitted (s11)	7	1		3	-	-	-	-	1	-	1	-	-	-	-	-
**Wahlenbergia capensis*	*U*	R	Permitted (s11)	3	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-



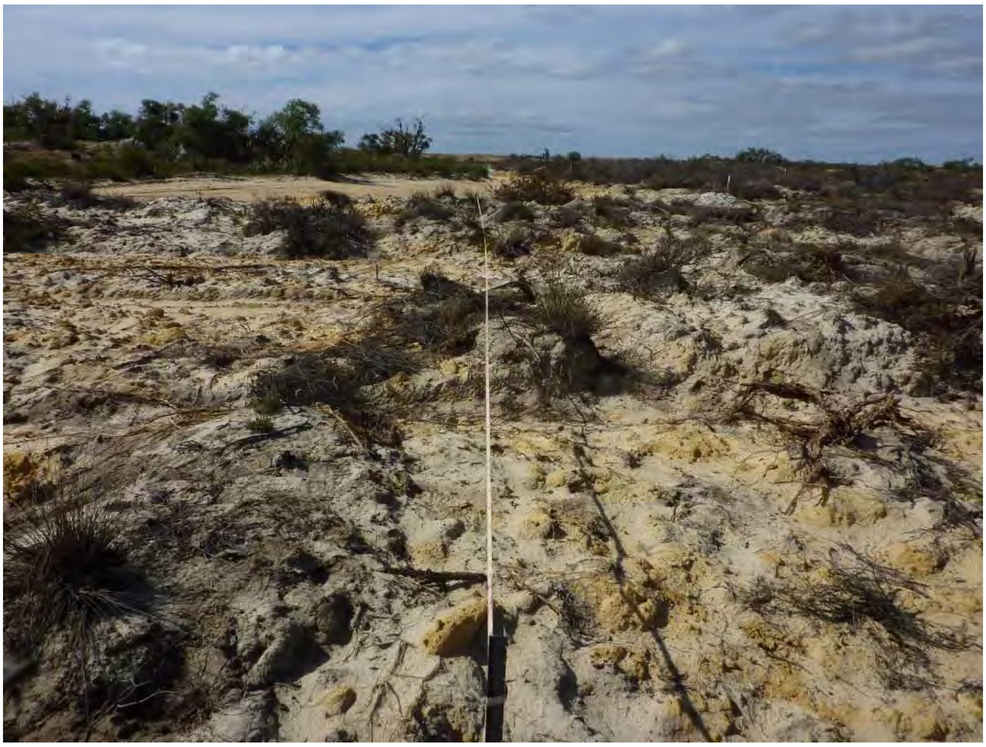
Photograph E1: VDT Treatment 1, Transect 1 START, October 2012

Photograph E2: VDT Treatment 1, Transect 1 START, September 2013

Photograph E3: VDT Treatment 1, Transect 1 START, October 2014

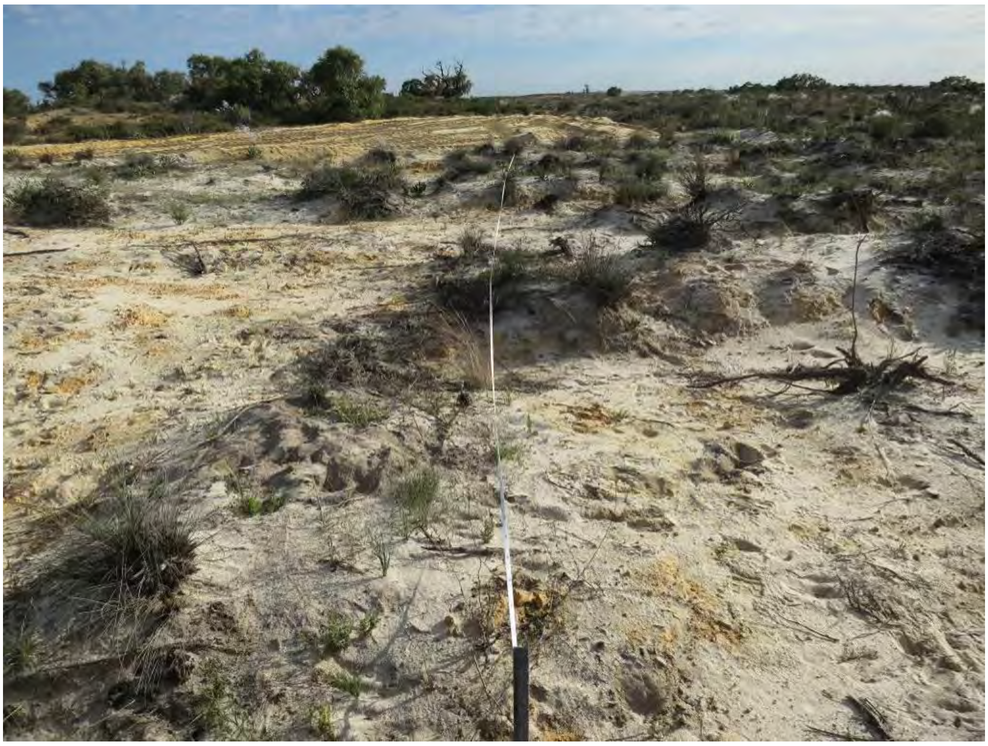
Photograph E4: VDT Treatment 1, Transect 1 START, September 2015

Photograph E5: VDT Treatment 1, Transect 1 START, October 2019



Photograph E6: VDT Treatment 1, Transect 1 END, October 2012

Photograph E7: VDT Treatment 1, Transect 1 END, September 2013

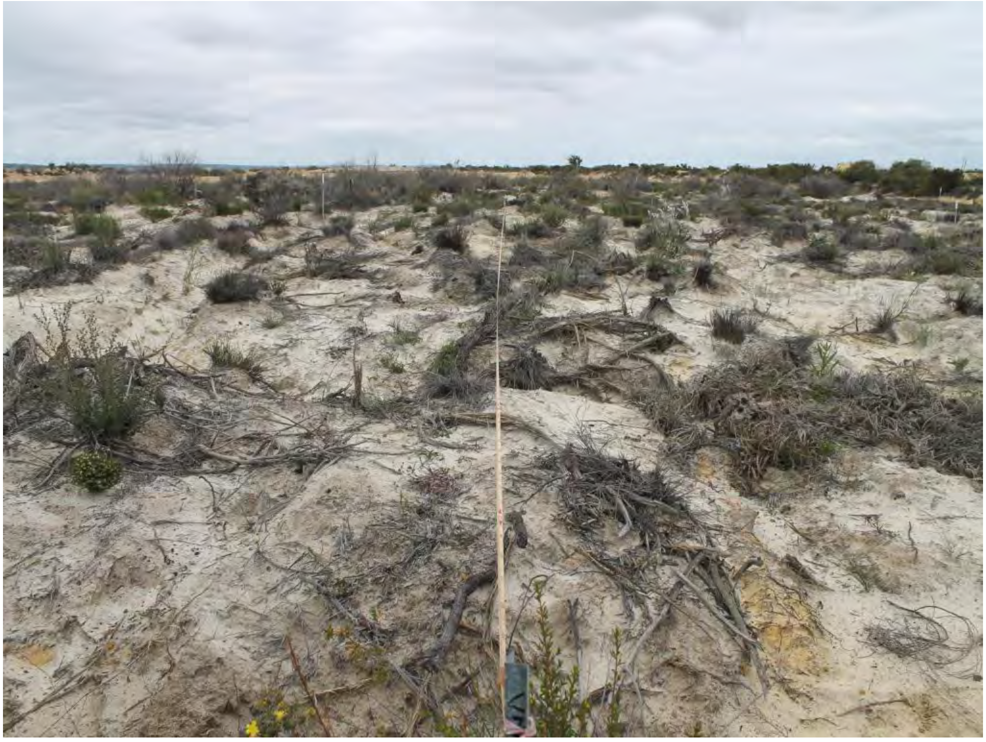


Photograph E8: VDT Treatment 1, Transect 1 END, October 2014

Photograph E9: VDT Treatment 1, Transect 1 END, September 2015

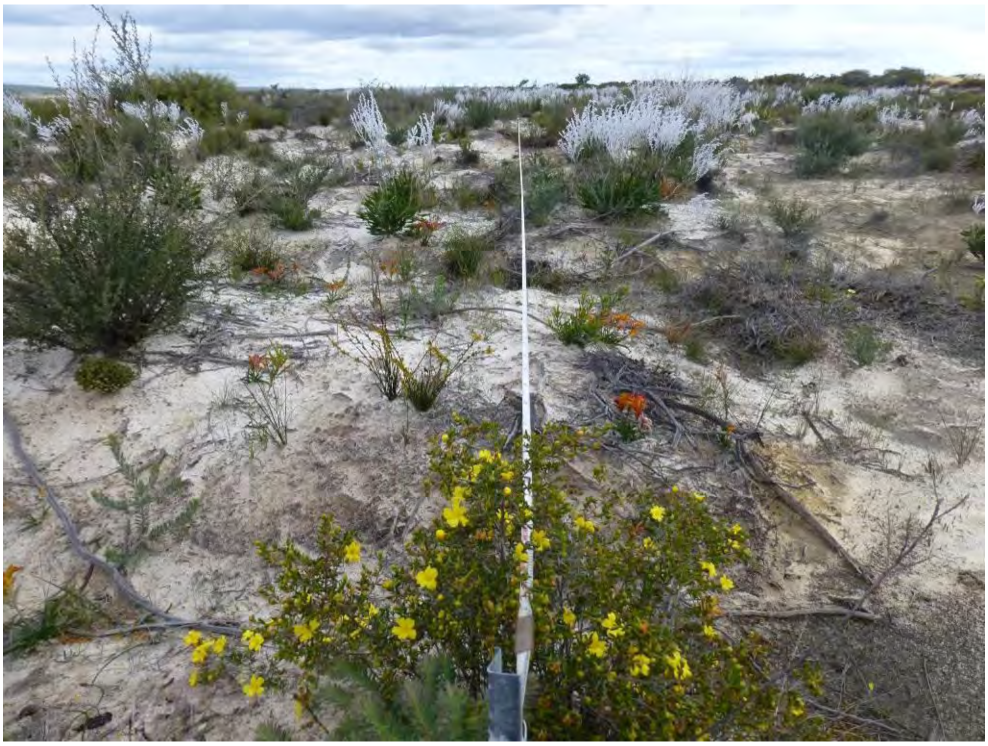
Photograph E10: VDT Treatment 1, Transect 1 END, October 2019

Photograph E11: VDT Treatment 1, Transect 2 START, October 2012



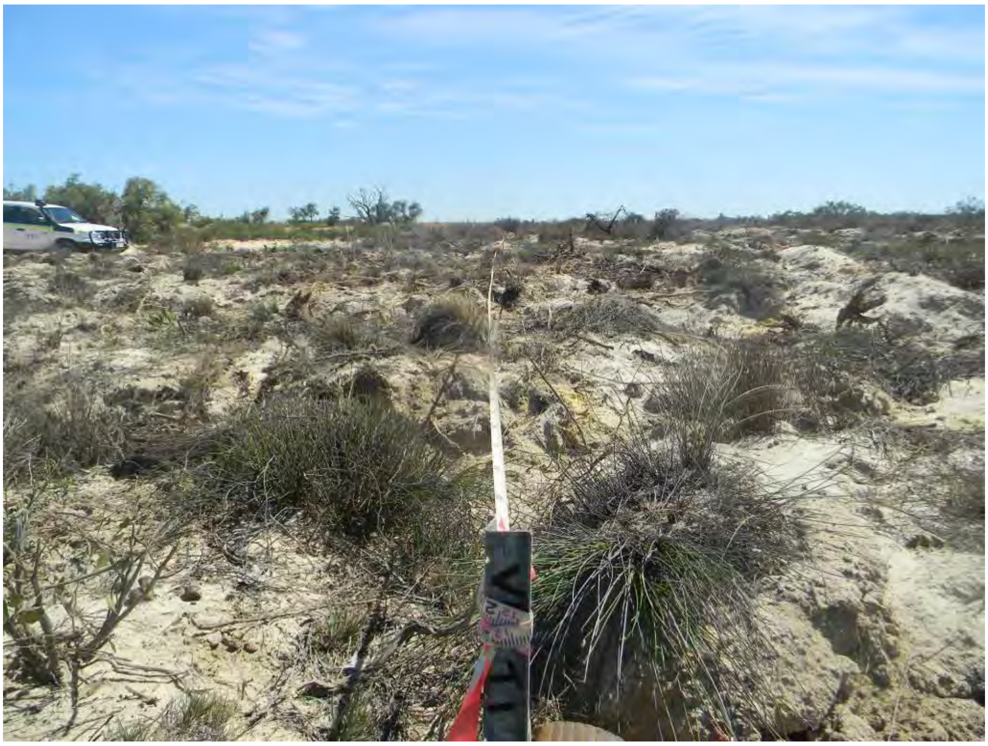
Photograph E12: VDT Treatment 1, Transect 2 START, September 2013

Photograph E13: VDT Treatment 1, Transect 2 START, October 2014



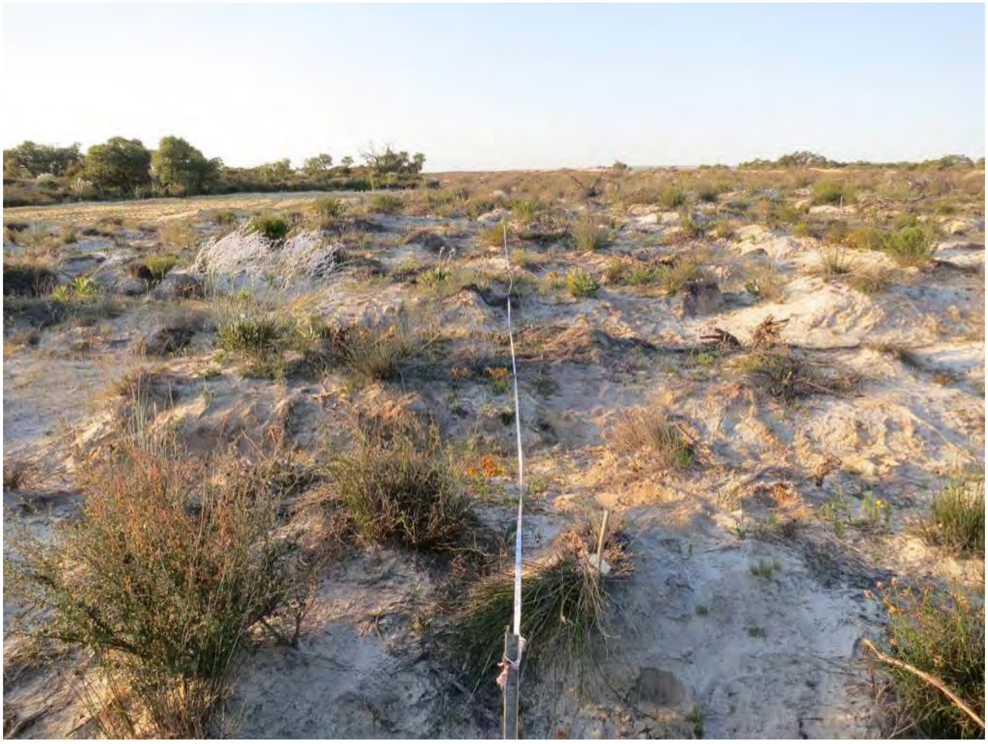
Photograph E14: VDT Treatment 1, Transect 2 START, September 2015

Photograph E15: VDT Treatment 1, Transect 2 START, October 2019



Photograph E16: VDT Treatment 1, Transect 2 END, October 2012

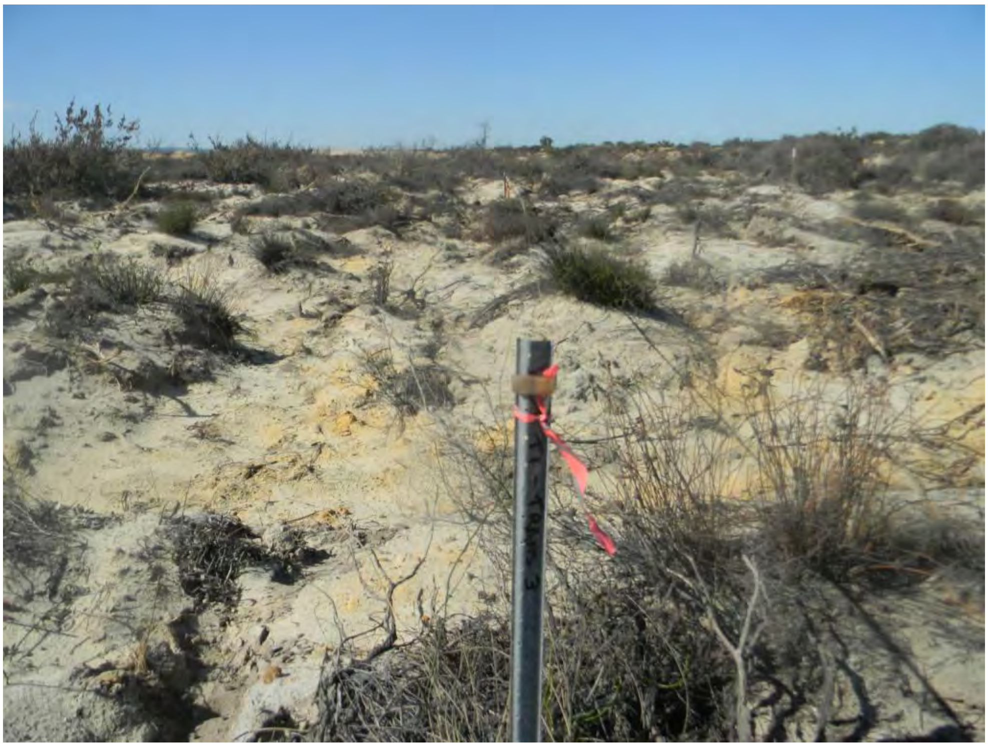
Photograph E17: VDT Treatment 1, Transect 2 END, September 2013



Photograph E18: VDT Treatment 1, Transect 2 END, October 2014

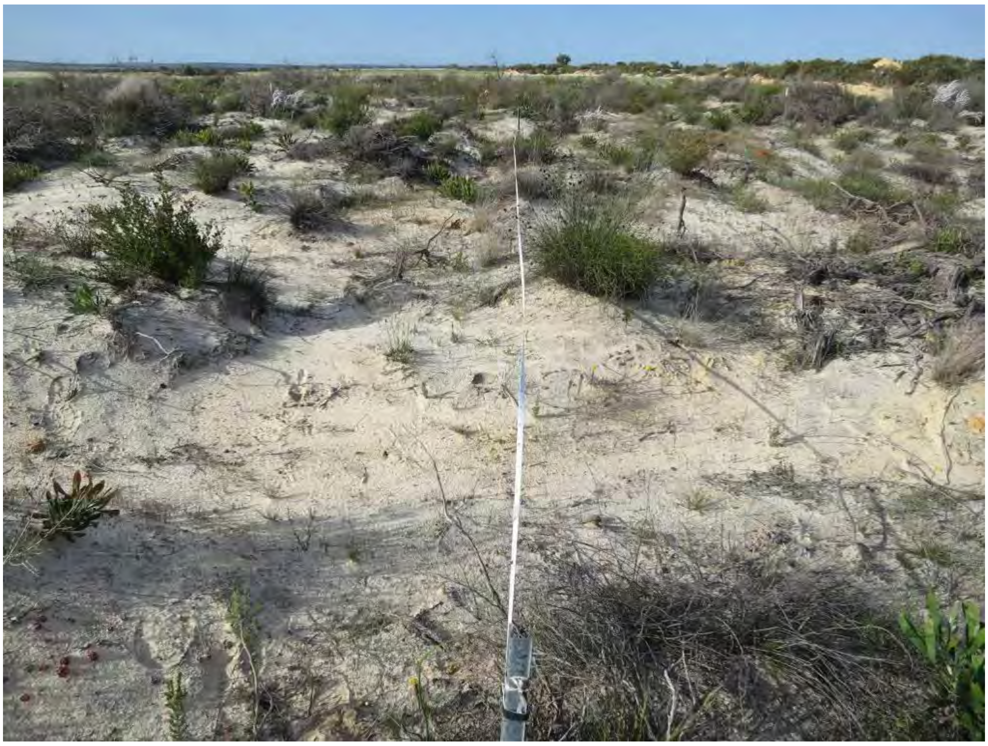
Photograph E19: VDT Treatment 1, Transect 2 END, September 2015

Photograph E20: VDT Treatment 1, Transect 2 END, October 2019



Photograph E21: VDT Treatment 1, Transect 3 START, October 2012

Photograph E22: VDT Treatment 1, Transect 3 START, September 2013



Photograph E23: VDT Treatment 1, Transect 3 START, October 2014

Photograph E24: VDT Treatment 1, Transect 3 START, September 2015

Photograph E25: VDT Treatment 1, Transect 3 START, October 2019

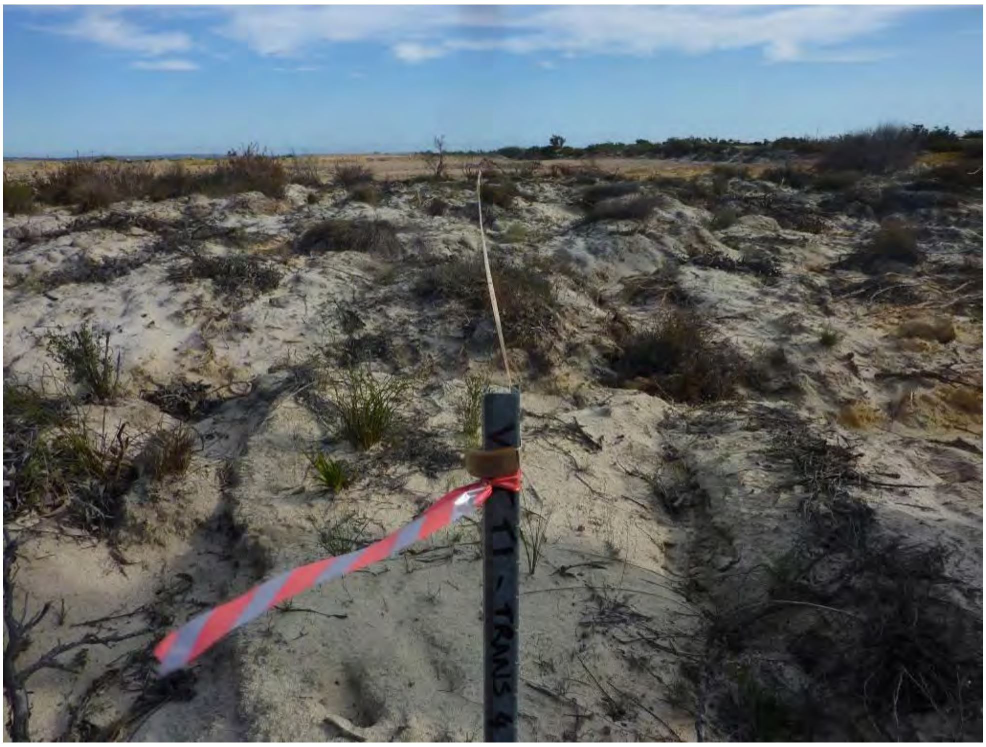
Photograph E26: VDT Treatment 1, Transect 3 END, October 2012

Photograph E27: VDT Treatment 1, Transect 3 END, September 2013

Photograph E28: VDT Treatment 1, Transect 3 END, October 2014

Photograph E29: VDT Treatment 1, Transect 3 END, September 2015

Photograph E30: VDT Treatment 1, Transect 3 END, October 2019



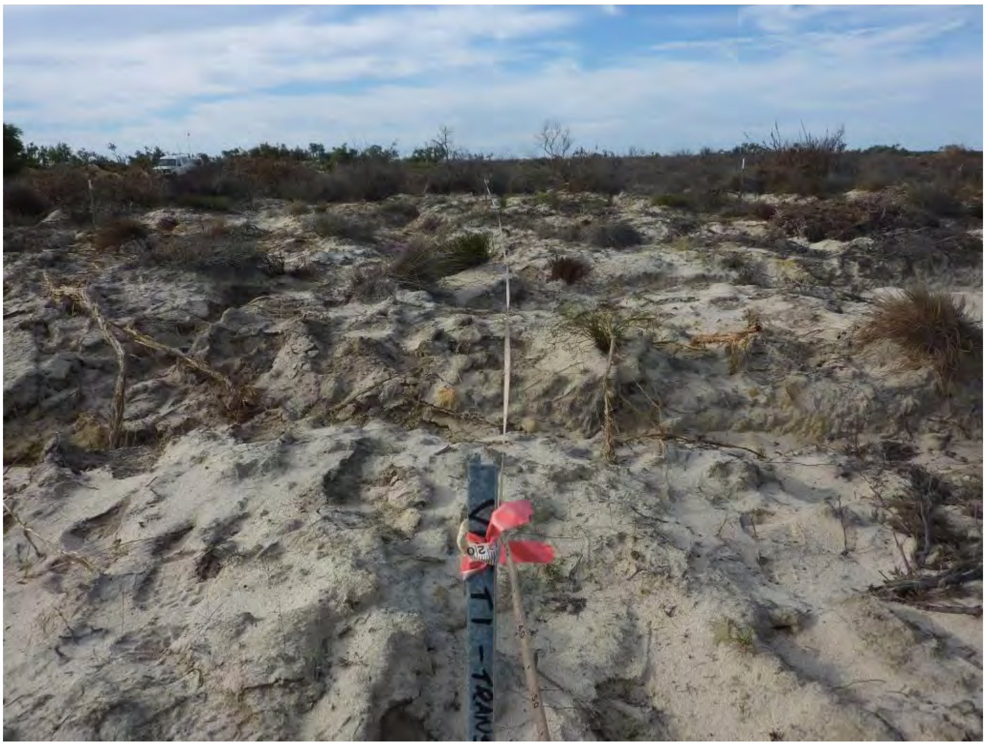
Photograph E31: VDT Treatment 1, Transect 4 START, October 2012

Photograph E32: VDT Treatment 1, Transect 4 START, September 2013

Photograph E33: VDT Treatment 1, Transect 4 START, October 2014

Photograph E34: VDT Treatment 1, Transect 4 START, September 2015

Photograph E35: VDT Treatment 1, Transect 4 START, October 2019



Photograph E36: VDT Treatment 1, Transect 4 END, October 2012

Photograph E37: VDT Treatment 1, Transect 4 END, September 2013

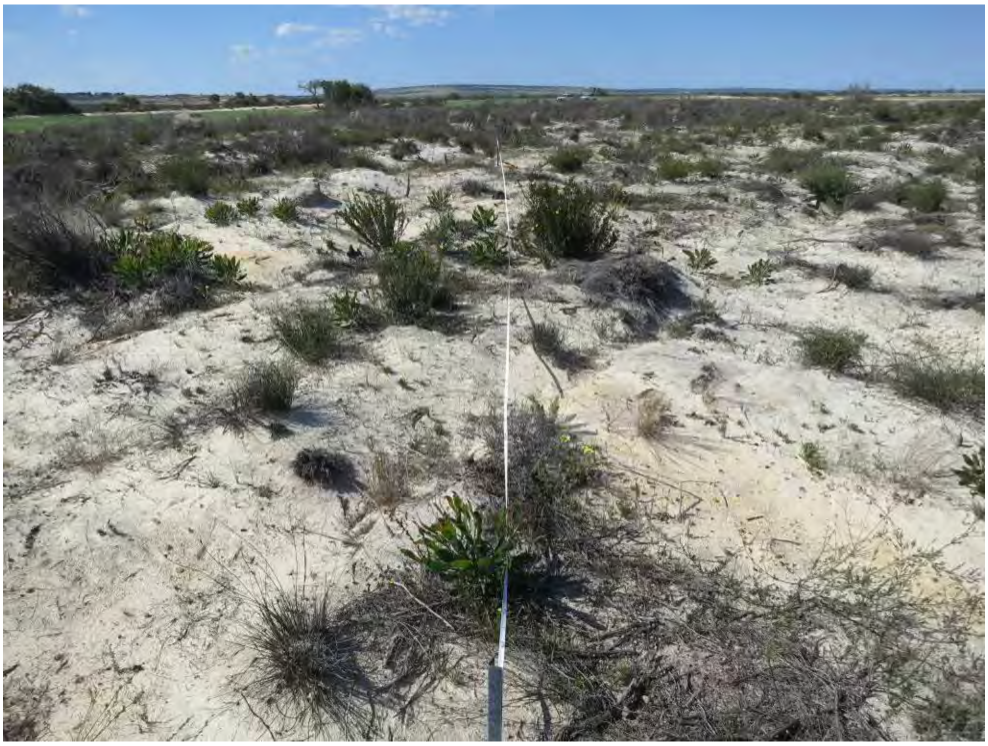
Photograph E38: VDT Treatment 1, Transect 4 END, October 2014

Photograph E39: VDT Treatment 1, Transect 4 END, September 2015

Photograph E40: VDT Treatment 1, Transect 4 END, October 2019

Photograph E41: VDT Treatment 2, Transect 1 START, October 2012

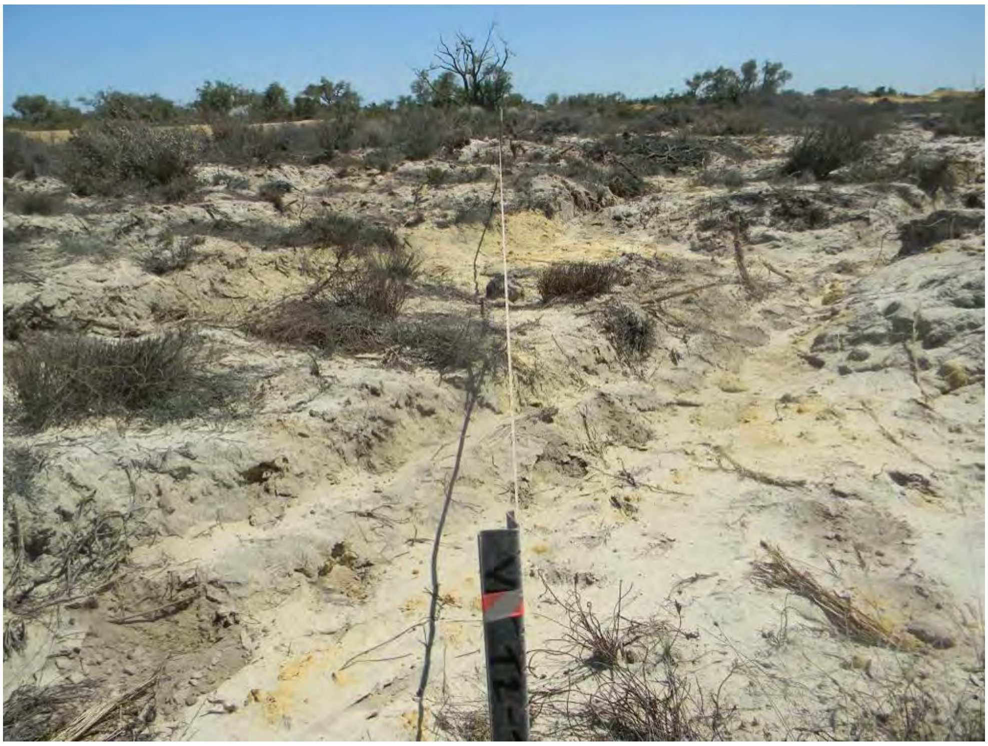
Photograph E42: VDT Treatment 2, Transect 1 START, September 2013



Photograph E43: VDT Treatment 2, Transect 1 START, October 2014

Photograph E44: VDT Treatment 2, Transect 1 START, September 2015

Photograph E45: VDT Treatment 2, Transect 1 START, October 2019



Photograph E46: VDT Treatment 2, Transect 1 END, October 2012

Photograph E47: VDT Treatment 2, Transect 1 END, September 2013

Photograph E48: VDT Treatment 2, Transect 1 END, October 2014

Photograph E49: VDT Treatment 2, Transect 1 END, September 2015

Photograph E50: VDT Treatment 2, Transect 1 END, October 2019

Photograph E51: VDT Treatment 2, Transect 2 START, October 2012

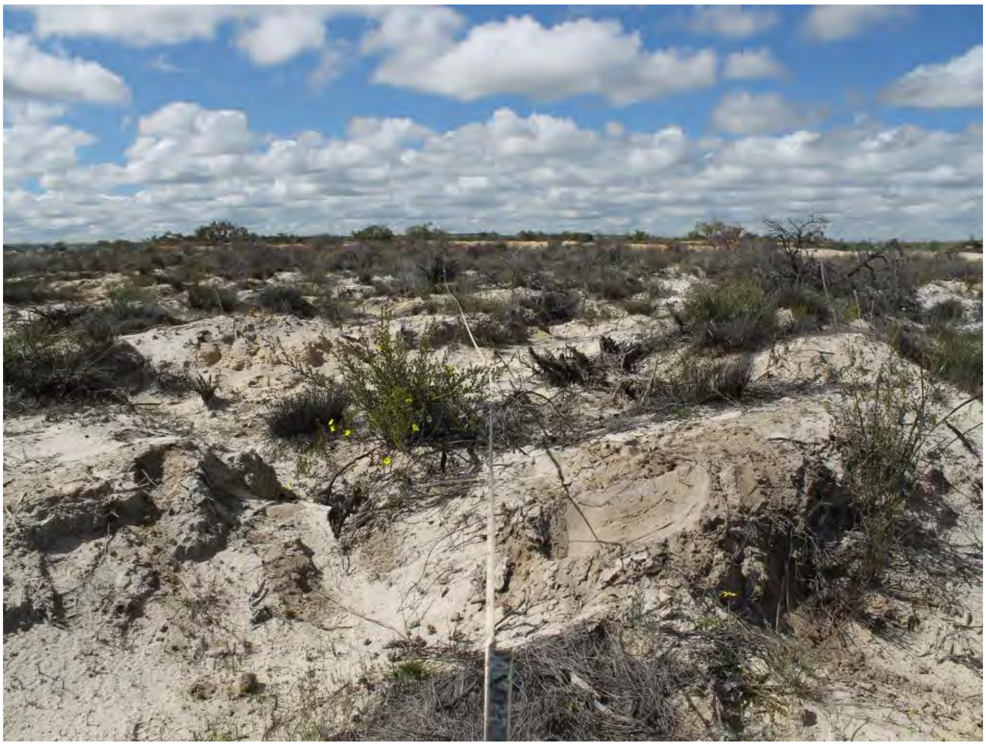
Photograph E52: VDT Treatment 2, Transect 2 START, September 2013

Photograph E53: VDT Treatment 2, Transect 2 START, October 2014

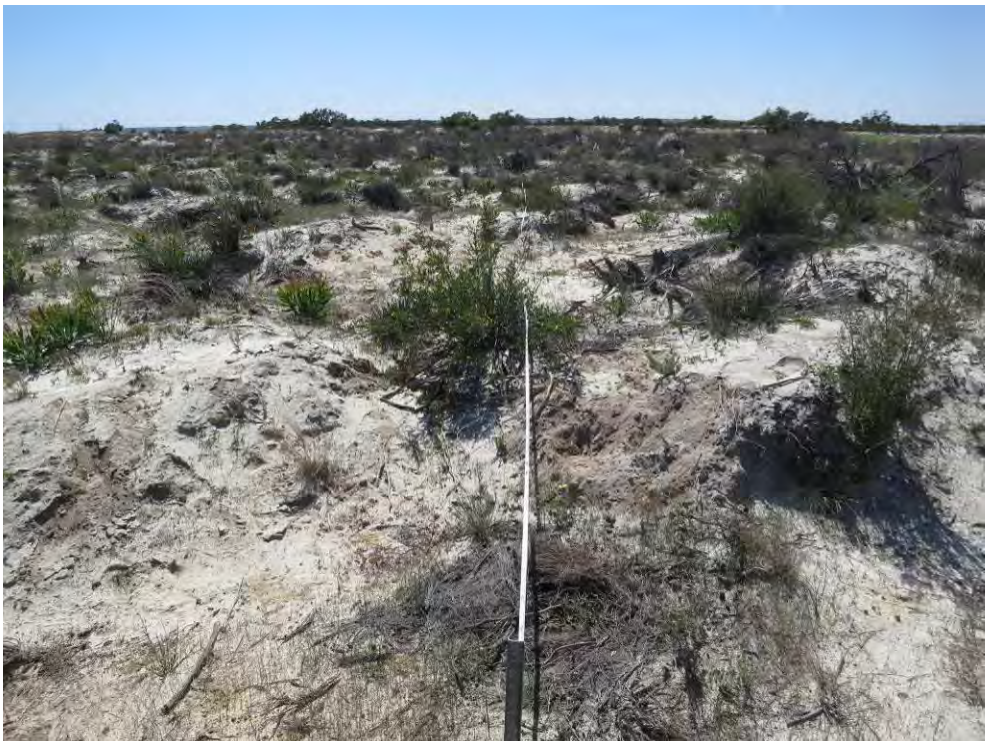
Photograph E54: VDT Treatment 2, Transect 2 START, September 2015

Photograph E55: VDT Treatment 2, Transect 2 START, October 2019

Photograph E56: VDT Treatment 2, Transect 2 END, October 2012



Photograph E57: VDT Treatment 2, Transect 2 END, September 2013



Photograph E58: VDT Treatment 2, Transect 2 END, October 2014

Photograph E59: VDT Treatment 2, Transect 2 END, September 2015

Photograph E60: VDT Treatment 2, Transect 2 END, October 2019

Photograph E61: VDT Treatment 2, Transect 3 START, October 2012

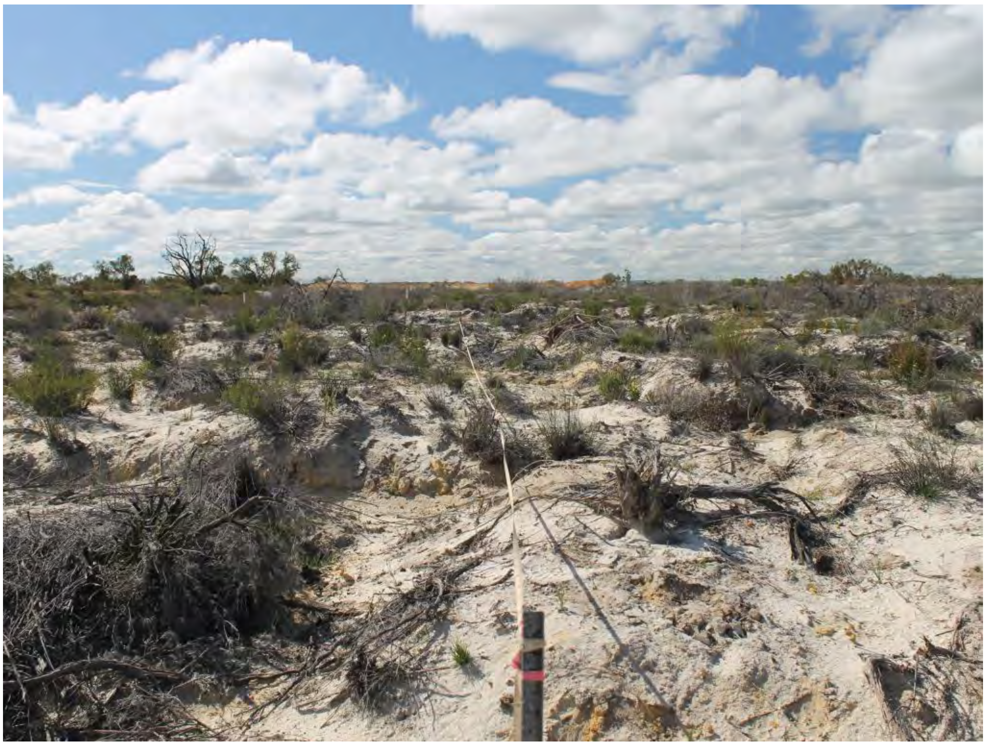
Photograph E62: VDT Treatment 2, Transect 3 START, September 2013

Photograph E63: VDT Treatment 2, Transect 3 START, October 2014

Photograph E64: VDT Treatment 2, Transect 3 START, September 2015

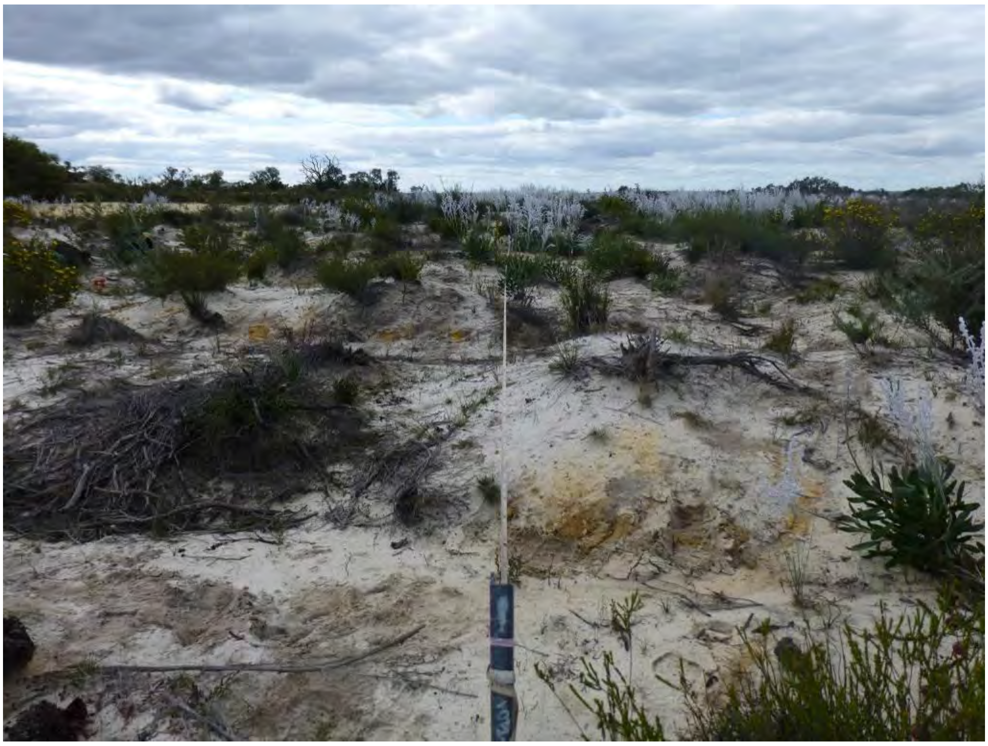
Photograph E65: VDT Treatment 2, Transect 3 START, October 2019

Photograph E66: VDT Treatment 2, Transect 3 END, October 2012



Photograph E67: VDT Treatment 2, Transect 3 END, September 2013

Photograph E68: VDT Treatment 2, Transect 3 END, October 2014



Photograph E69: VDT Treatment 2, Transect 3 END, September 2015

Photograph E70: VDT Treatment 2, Transect 3 END, October 2019

Photograph E71: VDT Treatment 2, Transect 4 START, October 2012

Photograph E72: VDT Treatment 2, Transect 4 START, September 2013

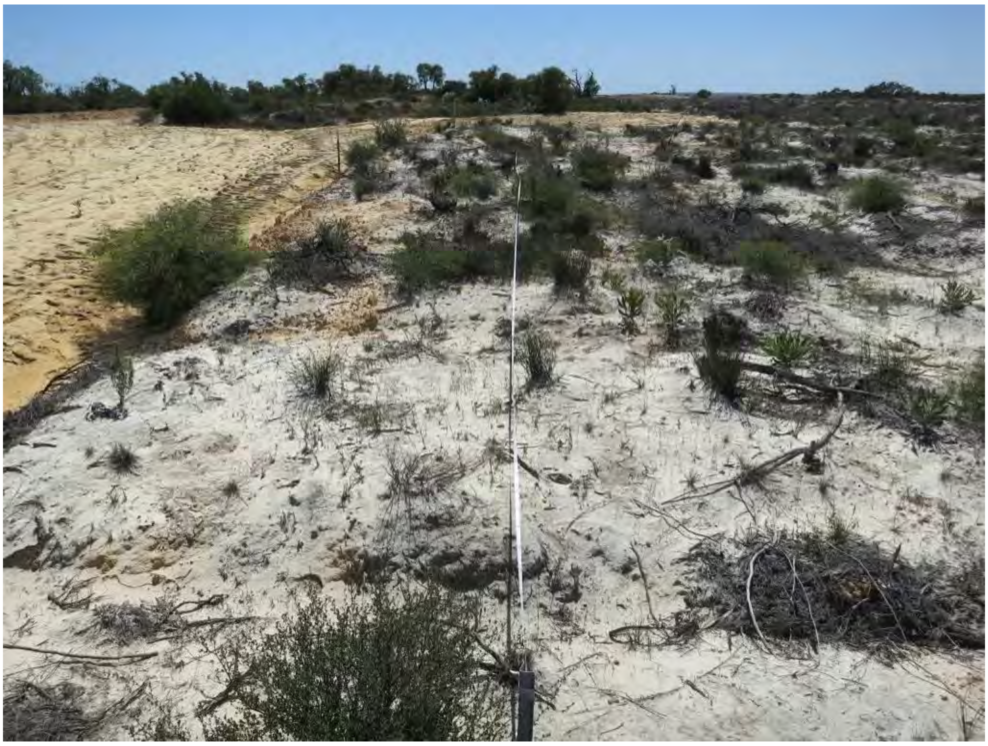
Photograph E73: VDT Treatment 2, Transect 4 START, October 2014

Photograph E74: VDT Treatment 2, Transect 4 START, September 2015

Photograph E75: VDT Treatment 2, Transect 4 START, October 2019

Photograph E76: VDT Treatment 2, Transect 4 END, October 2012

Photograph E77: VDT Treatment 2, Transect 4 END, September 2013



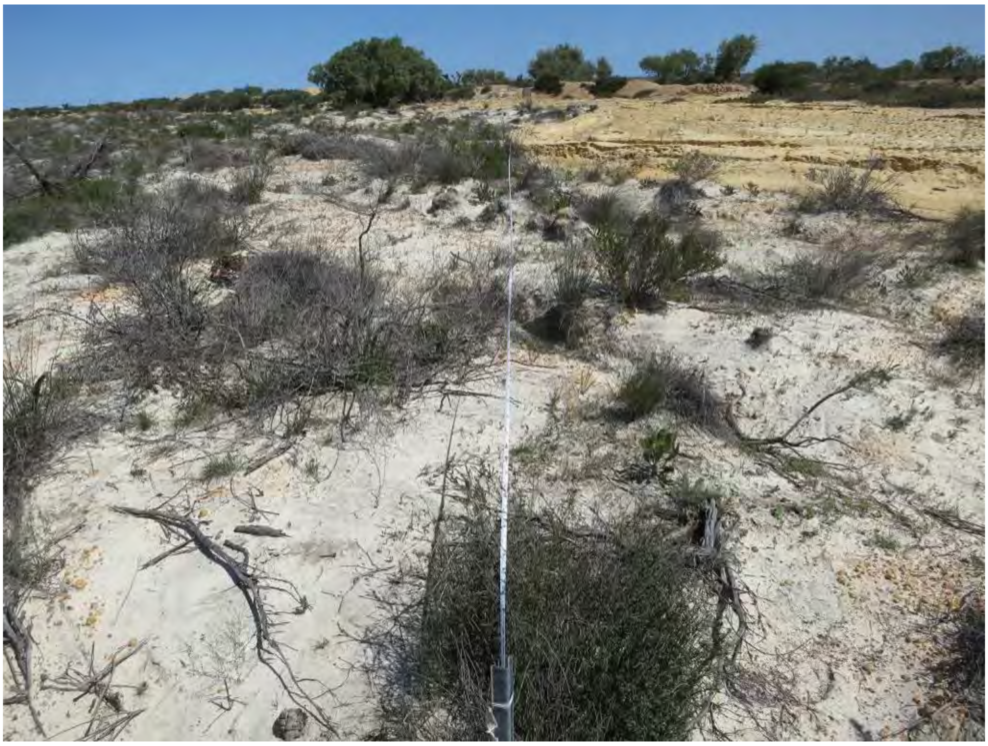
Photograph E78: VDT Treatment 2, Transect 4 END, October 2014

Photograph E79: VDT Treatment 2, Transect 4 END, September 2015

Photograph E80: VDT Treatment 2, Transect 4 END, October 2019

Photograph E81: VDT Treatment 3, Transect 1 START, October 2012

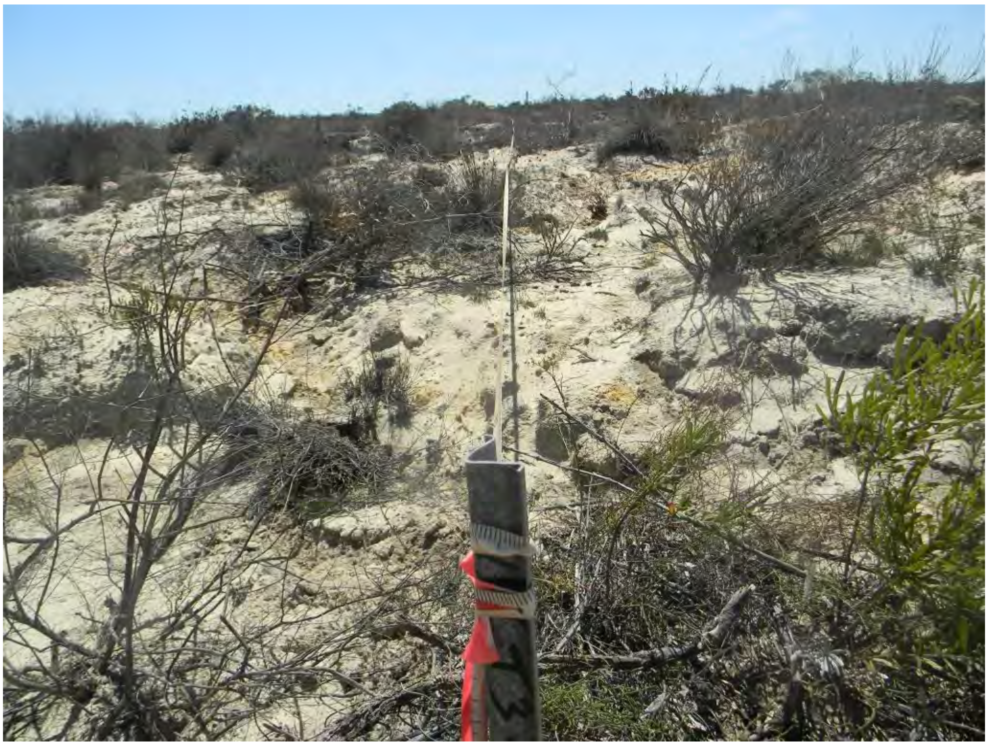
Photograph E82: VDT Treatment 3, Transect 1 START, September 2013



Photograph E83: VDT Treatment 3, Transect 1 START, October 2014

Photograph E84: VDT Treatment 3, Transect 1 START, September 2015

Photograph E85: VDT Treatment 3, Transect 1 START, October 2019



Photograph E86: VDT Treatment 3, Transect 1 END, October 2012

Photograph E87: VDT Treatment 3, Transect 1 END, September 2013

Photograph E88: VDT Treatment 3, Transect 1 END, October 2014

Photograph E89: VDT Treatment 3, Transect 1 END, September 2015

Photograph E90: VDT Treatment 3, Transect 1 END, October 2019

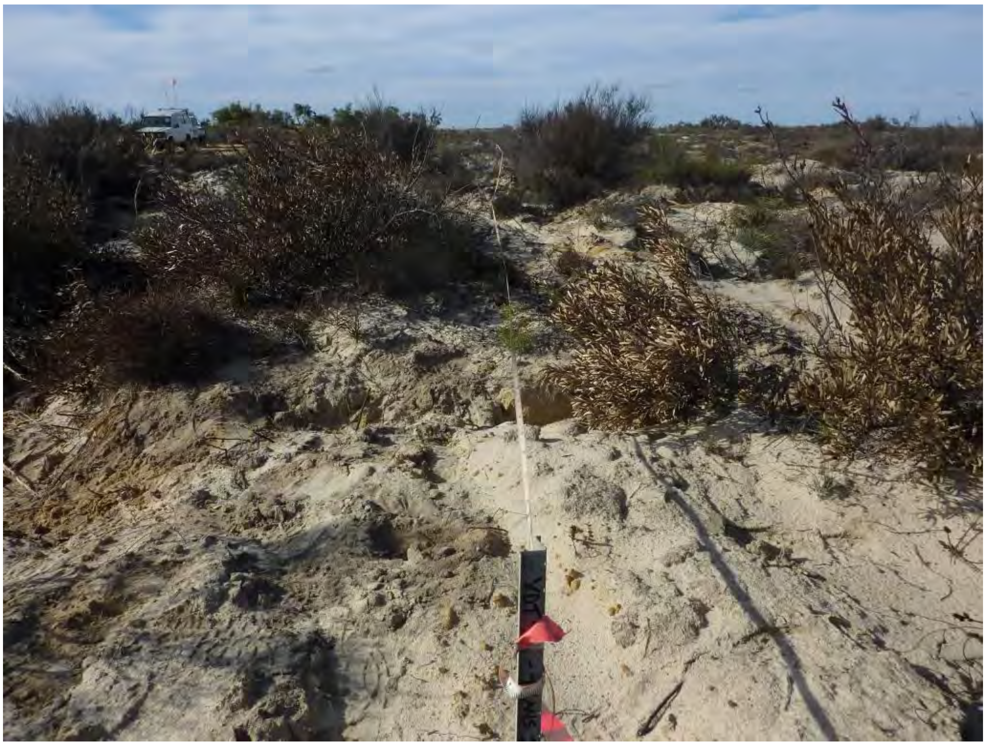
Photograph E91: VDT Treatment 3, Transect 2 START, October 2012

Photograph E92: VDT Treatment 3, Transect 2 START, September 2013

Photograph E93: VDT Treatment 3, Transect 2 START, October 2014

Photograph E94: VDT Treatment 3, Transect 2 START, September 2015

Photograph E95: VDT Treatment 3, Transect 2 START, October 2019



Photograph E96: VDT Treatment 3, Transect 2 END, October 2012

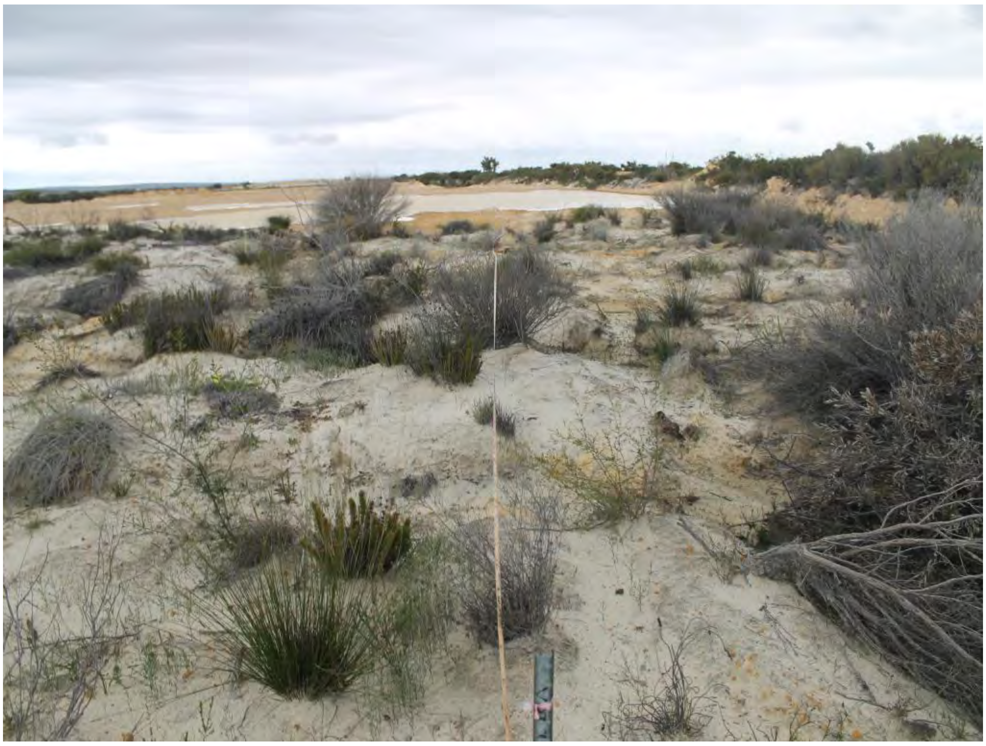
Photograph E97: VDT Treatment 3, Transect 2 END, September 2013

Photograph E98: VDT Treatment 3, Transect 2 END, October 2014

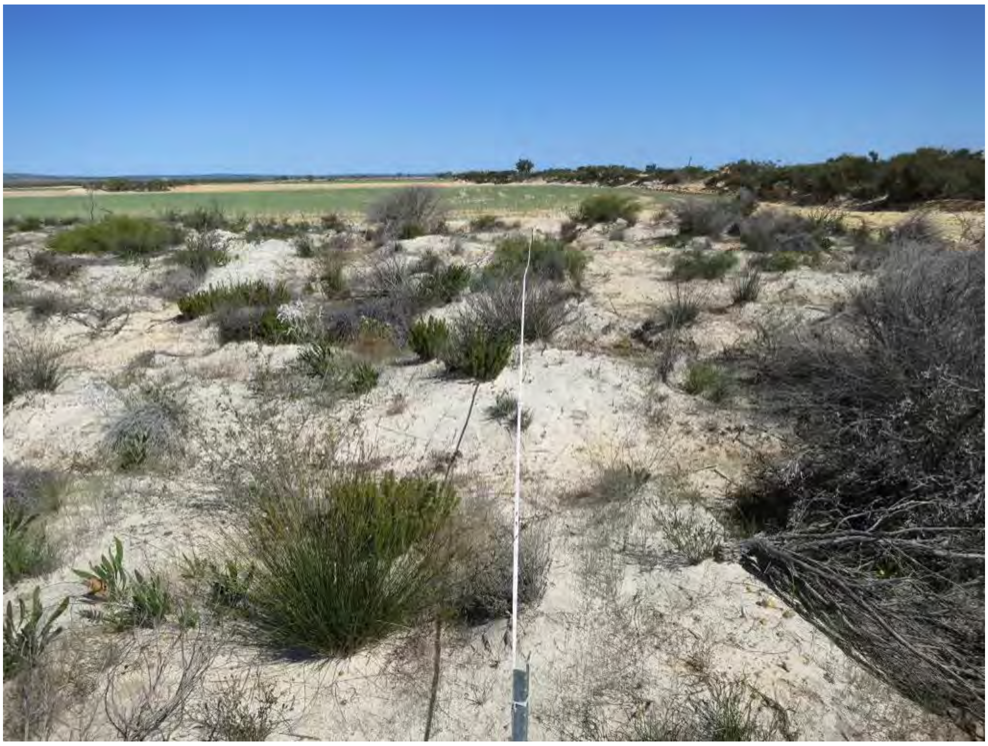
Photograph E99: VDT Treatment 3, Transect 2 END, September 2015

Photograph E100: VDT Treatment 3, Transect 2 END, October 2019

Photograph E101: VDT Treatment 3, Transect 3 START, October 2012



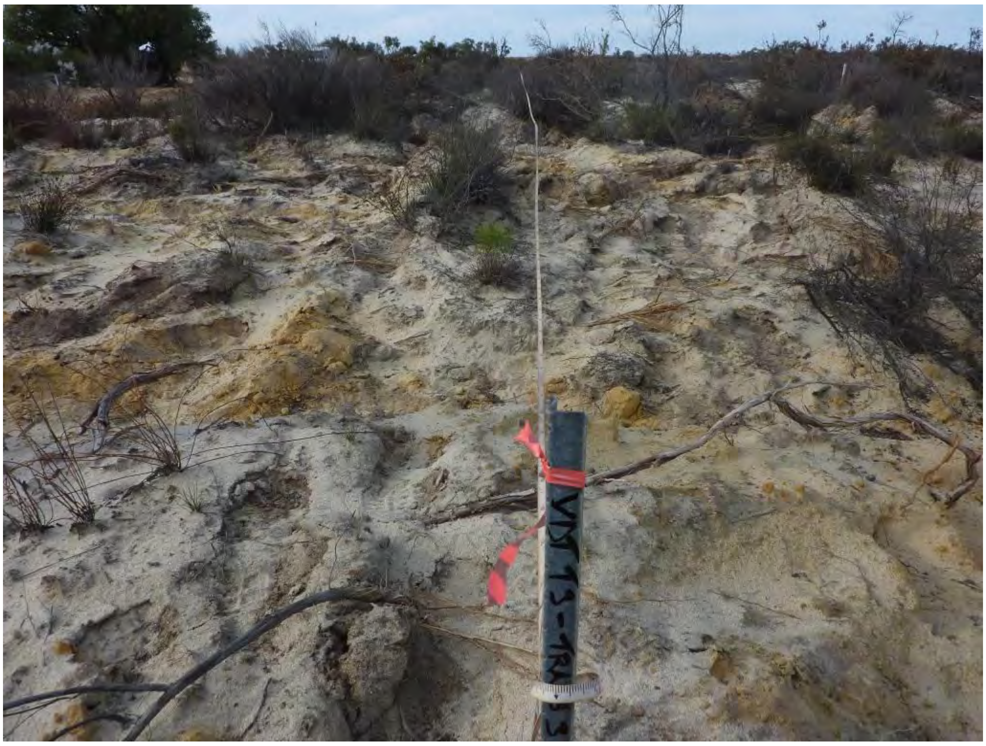
Photograph E102: VDT Treatment 3, Transect 3 START, September 2013



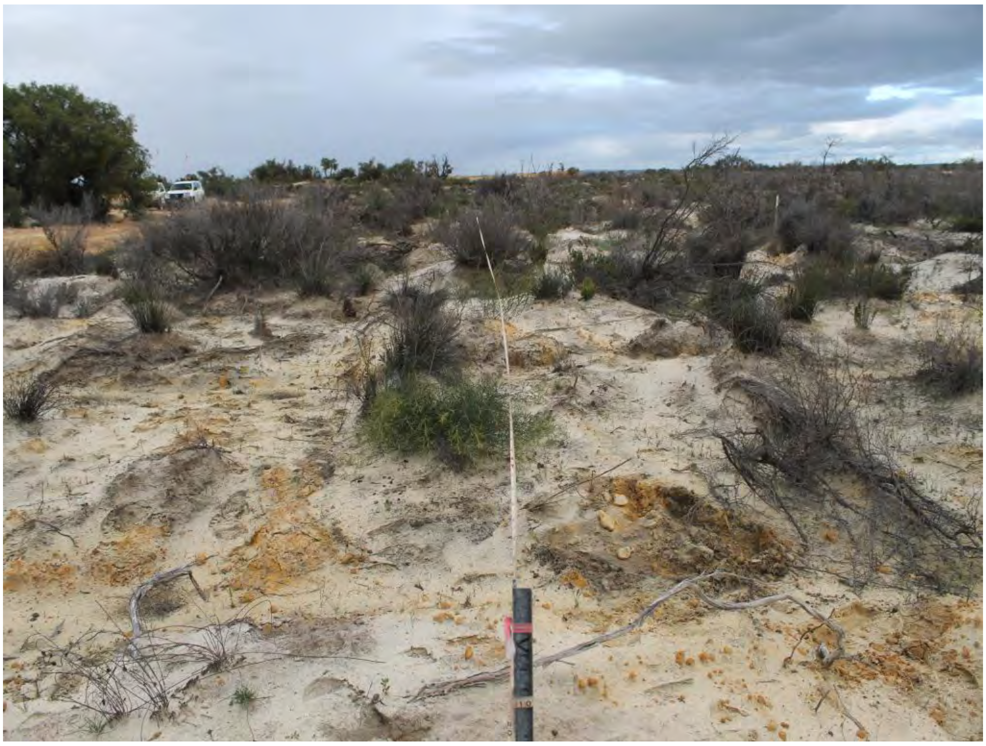
Photograph E103: VDT Treatment 3, Transect 3 START, October 2014

Photograph E104: VDT Treatment 3, Transect 3 START, September 2015

Photograph E105: VDT Treatment 3, Transect 3 START, October 2019



Photograph E106: VDT Treatment 3, Transect 3 END, October 2012



Photograph E107: VDT Treatment 3, Transect 3 END, September 2013

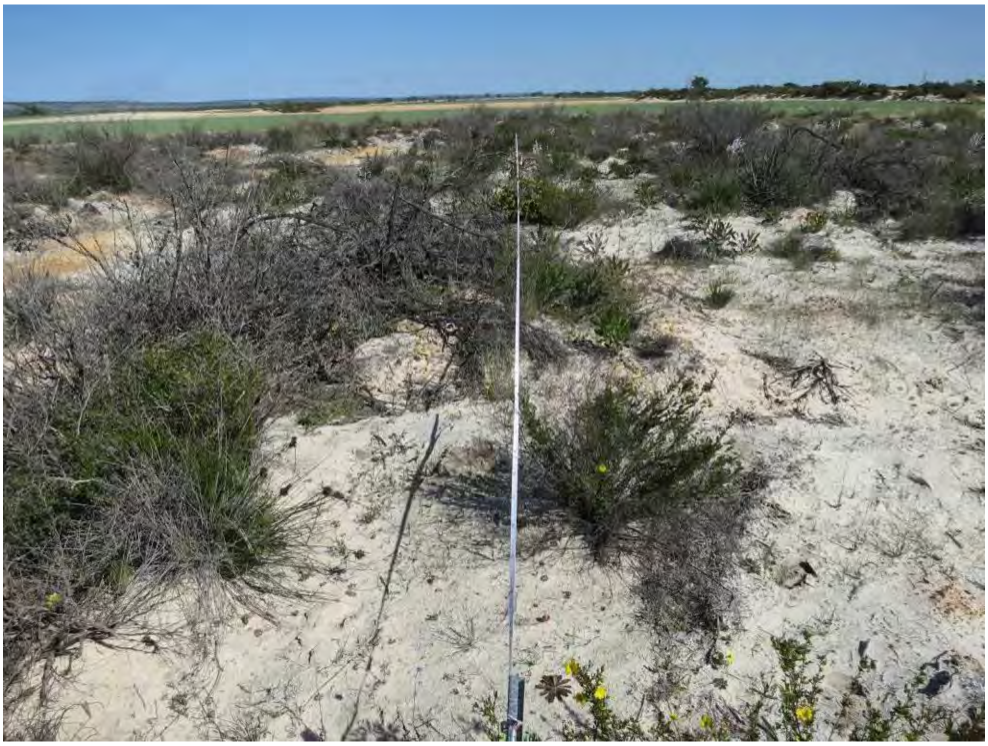
Photograph E108: VDT Treatment 3, Transect 3 END, October 2014

Photograph E109: VDT Treatment 3, Transect 3 END, September 2015

Photograph E110: VDT Treatment 3, Transect 3 END, October 2019

Photograph E111: VDT Treatment 3, Transect 4 START, October 2012

Photograph E112: VDT Treatment 3, Transect 4 START, September 2013



Photograph E113: VDT Treatment 3, Transect 4 START, October 2014

Photograph E114: VDT Treatment 3, Transect 4 START, September 2015

Photograph E115: VDT Treatment 3, Transect 4 START, October 2019

Photograph E116: VDT Treatment 3, Transect 4 END, October 2012

Photograph E117: VDT Treatment 3, Transect 4 END, September 2013

Photograph E118: VDT Treatment 3, Transect 4 END, October 2014

Photograph E119: VDT Treatment 3, Transect 4 START, September 2015

Photograph E120: VDT Treatment 3, Transect 4 START, October 2019

Photograph E121: VDT Treatment 4, Transect 1 START, October 2012

Photograph E122: VDT Treatment 4, Transect 1 START, September 2013

Photograph E123: VDT Treatment 4, Transect 1 START, October 2014

Photograph E124: VDT Treatment 4, Transect 1 START, September 2015

Photograph E125: VDT Treatment 4, Transect 1 START, October 2019

Photograph E126: VDT Treatment 4, Transect 1 END, October 2012

Photograph E127: VDT Treatment 4, Transect 1 END, September 2013

Photograph E128: VDT Treatment 4, Transect 1 END, October 2014

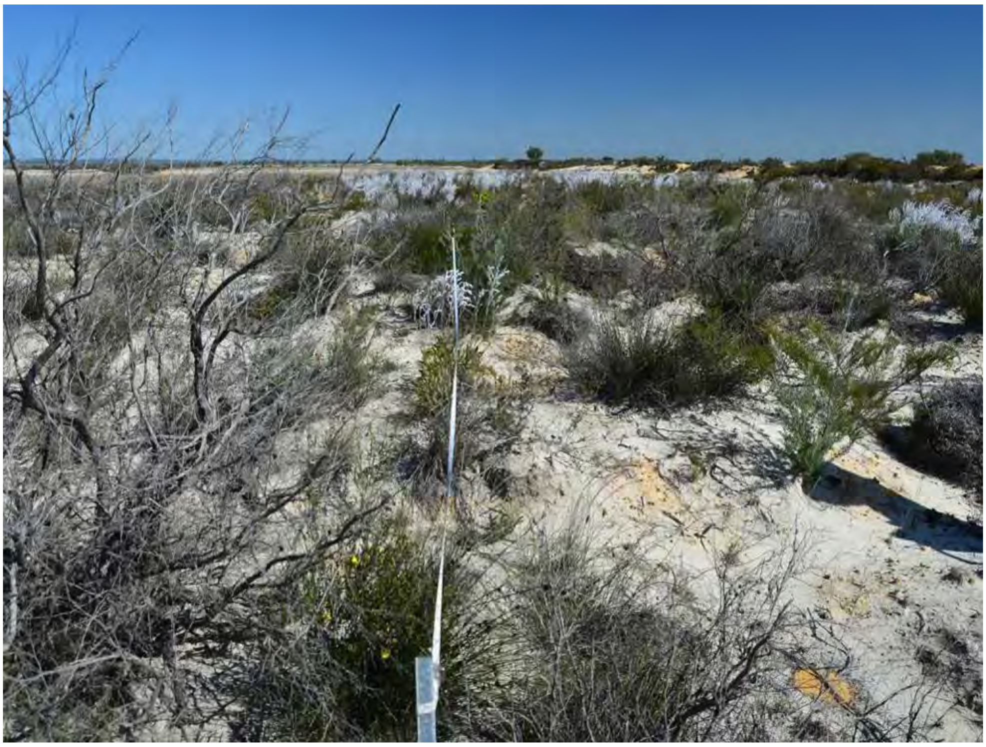
Photograph E129: VDT Treatment 4, Transect 1 END, September 2015

Photograph E130: VDT Treatment 4, Transect 1 END, October 2019

Photograph E131: VDT Treatment 4, Transect 2 START, October 2012

Photograph E132: VDT Treatment 4, Transect 2 START, September 2013

Photograph E133: VDT Treatment 4, Transect 2 START, October 2014



Photograph E134: VDT Treatment 4, Transect 2 START, September 2015

Photograph E135: VDT Treatment 4, Transect 2 START, October 2019

Photograph E136: VDT Treatment 4, Transect 2 END, October 2012

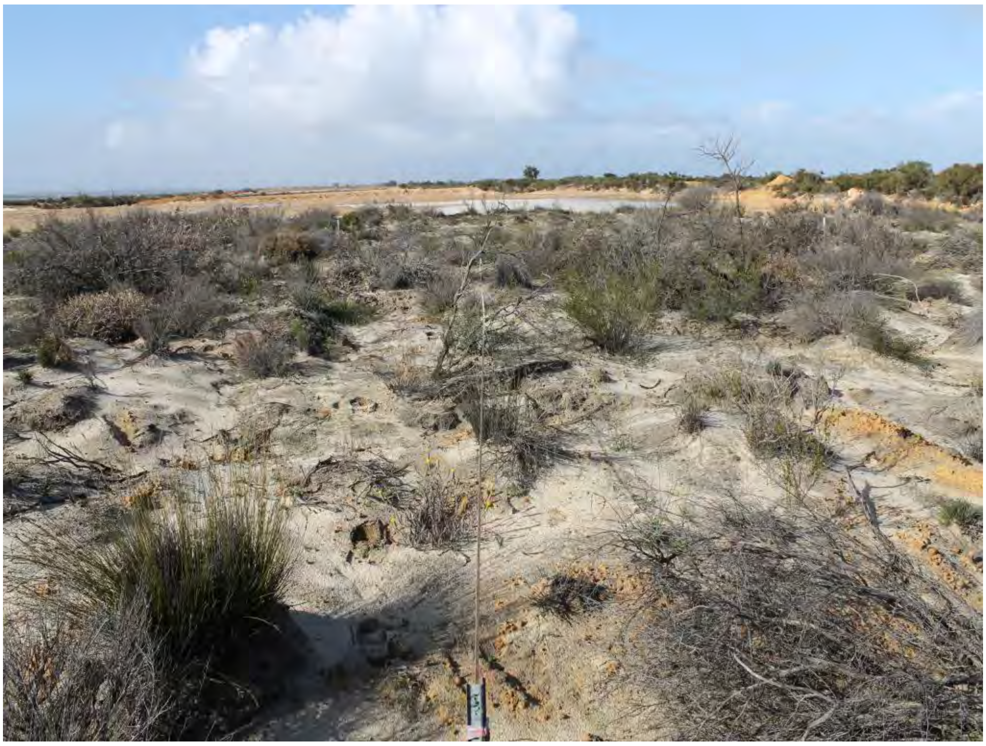
Photograph E137: VDT Treatment 4, Transect 2 END, September 2013

Photograph E138: VDT Treatment 4, Transect 2 END, October 2014

Photograph E139: VDT Treatment 4, Transect 2 END, September 2015

Photograph E140: VDT Treatment 4, Transect 2 END, October 2019

Photograph E141: VDT Treatment 4, Transect 3 START, October 2012

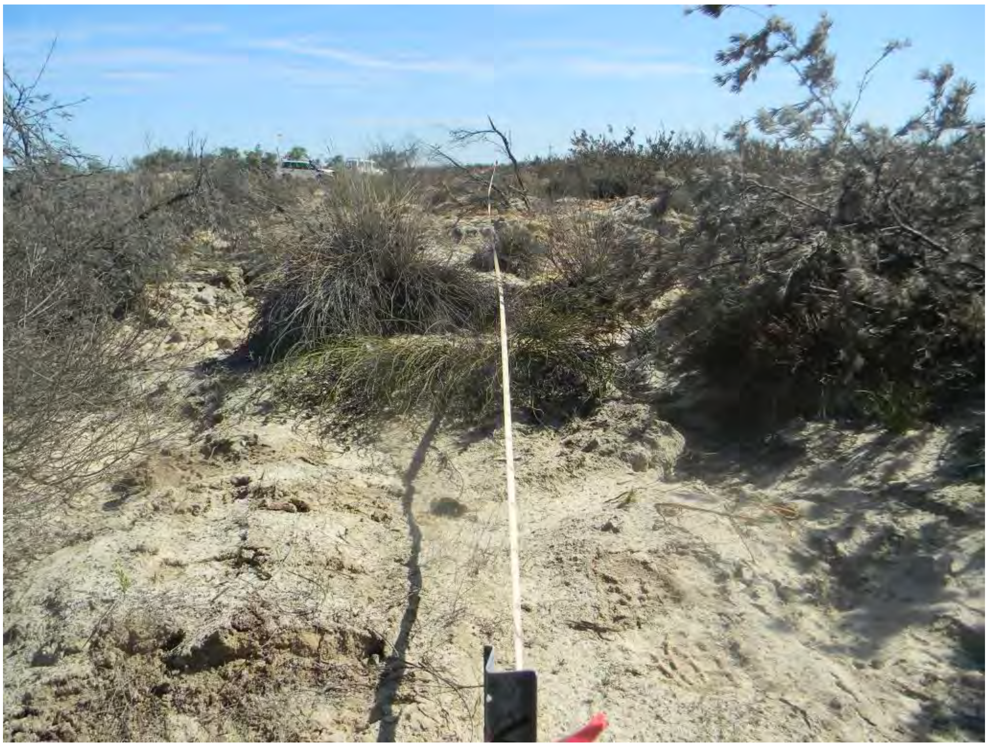


Photograph E142: VDT Treatment 4, Transect 3 START, September 2013

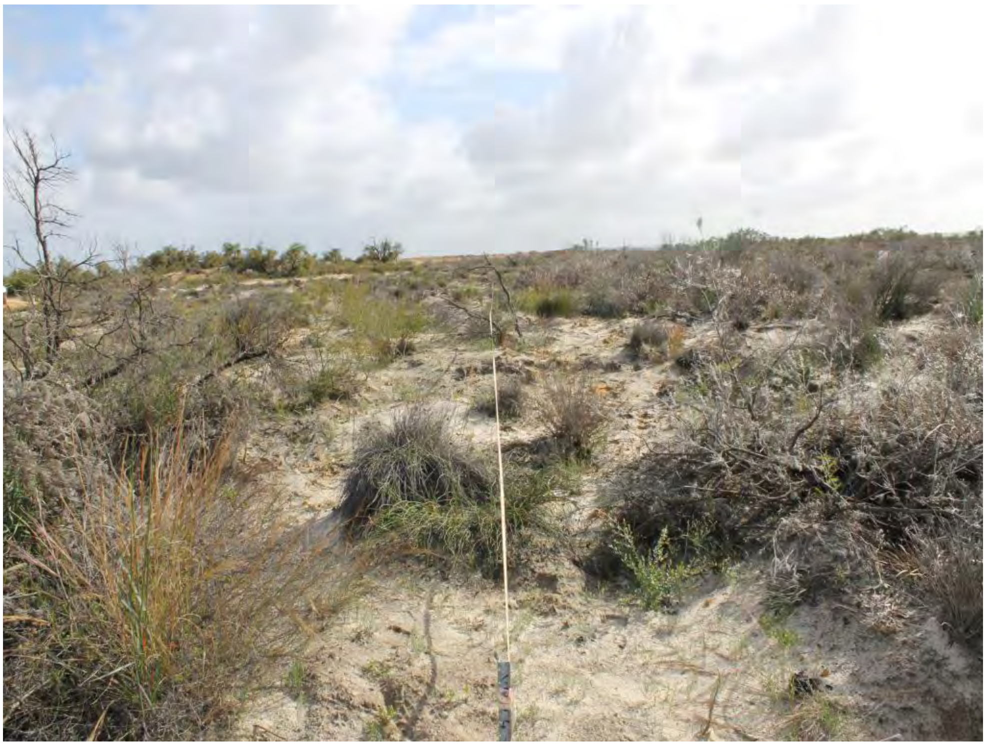
Photograph E143: VDT Treatment 4, Transect 3 START, October 2014

Photograph E144: VDT Treatment 4, Transect 3 START, September 2015

Photograph E145: VDT Treatment 4, Transect 3 START, October 2019



Photograph E146: VDT Treatment 4, Transect 3 END, October 2012

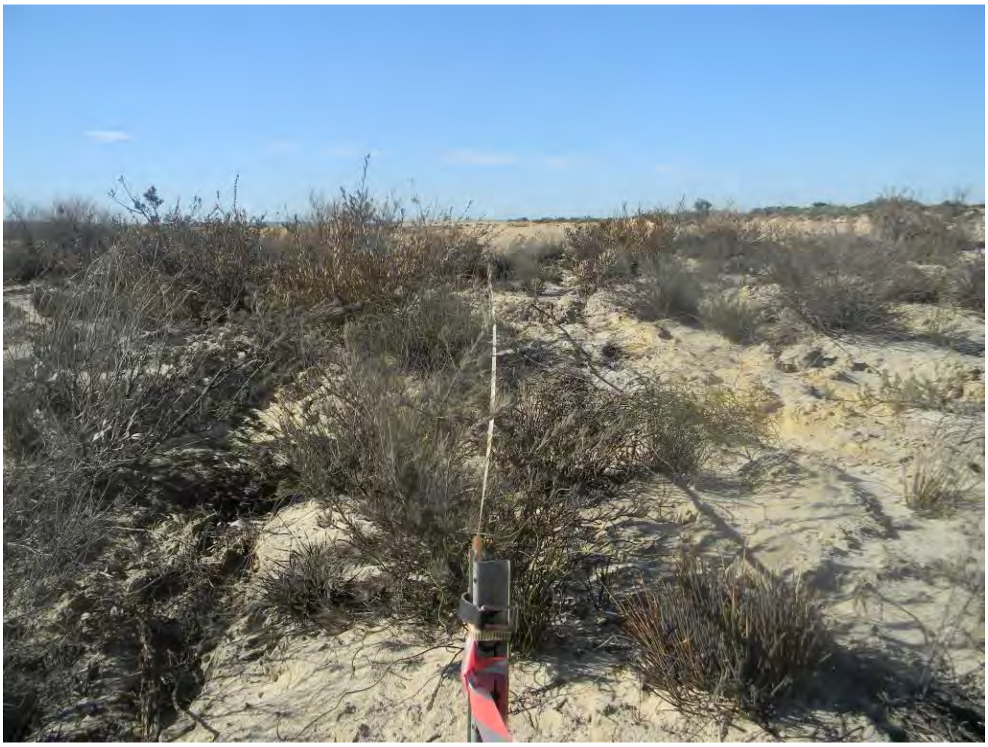


Photograph E147: VDT Treatment 4, Transect 3 END, September 2013

Photograph E148: VDT Treatment 4, Transect 3 END, October 2014

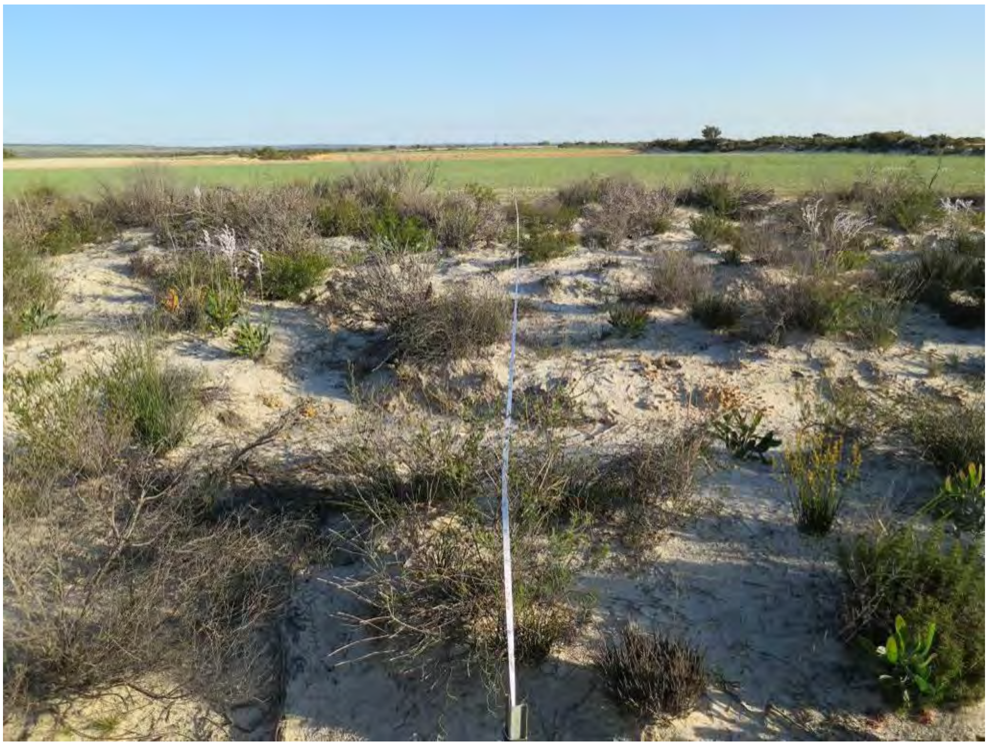
Photograph E149: VDT Treatment 4, Transect 3 END, September 2015

Photograph E150: VDT Treatment 4, Transect 3 END, October 2019



Photograph E151: VDT Treatment 4, Transect 4 START, October 2012

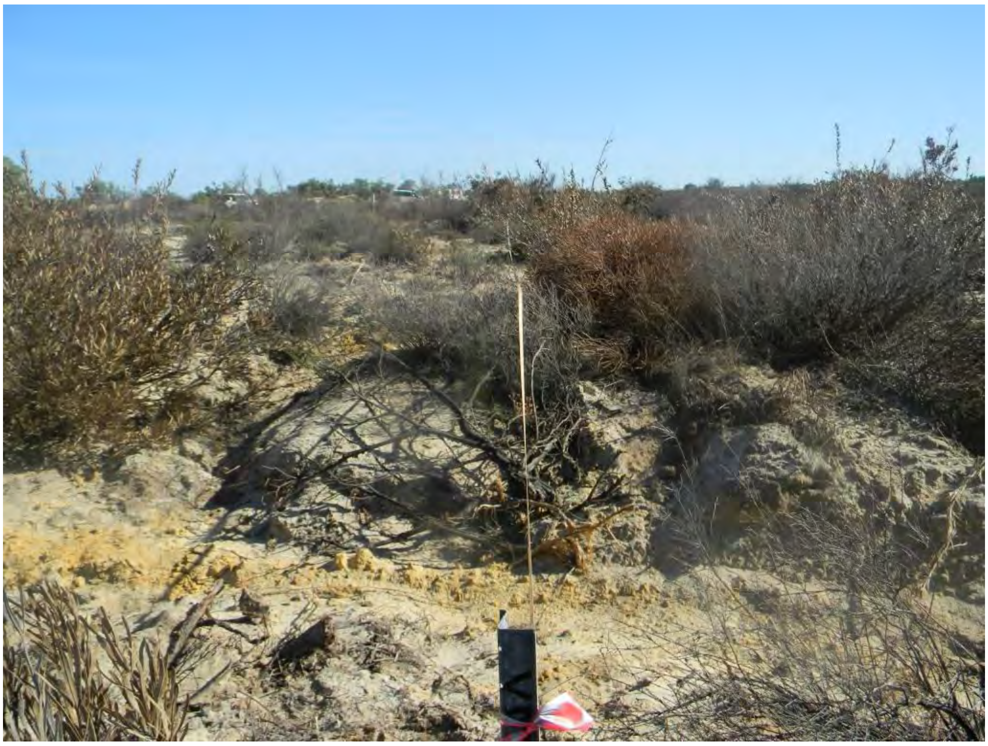
Photograph E152: VDT Treatment 4, Transect 4 START, September 2013



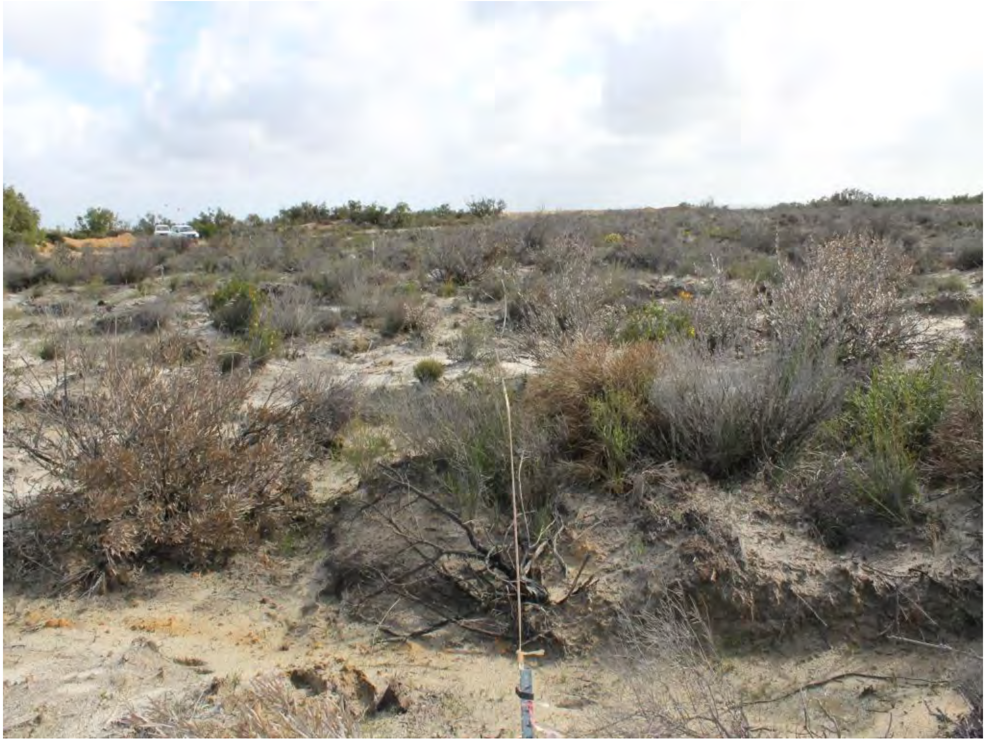
Photograph E153: VDT Treatment 4, Transect 4 START, October 2014

Photograph E154: VDT Treatment 4, Transect 4 START, September 2015

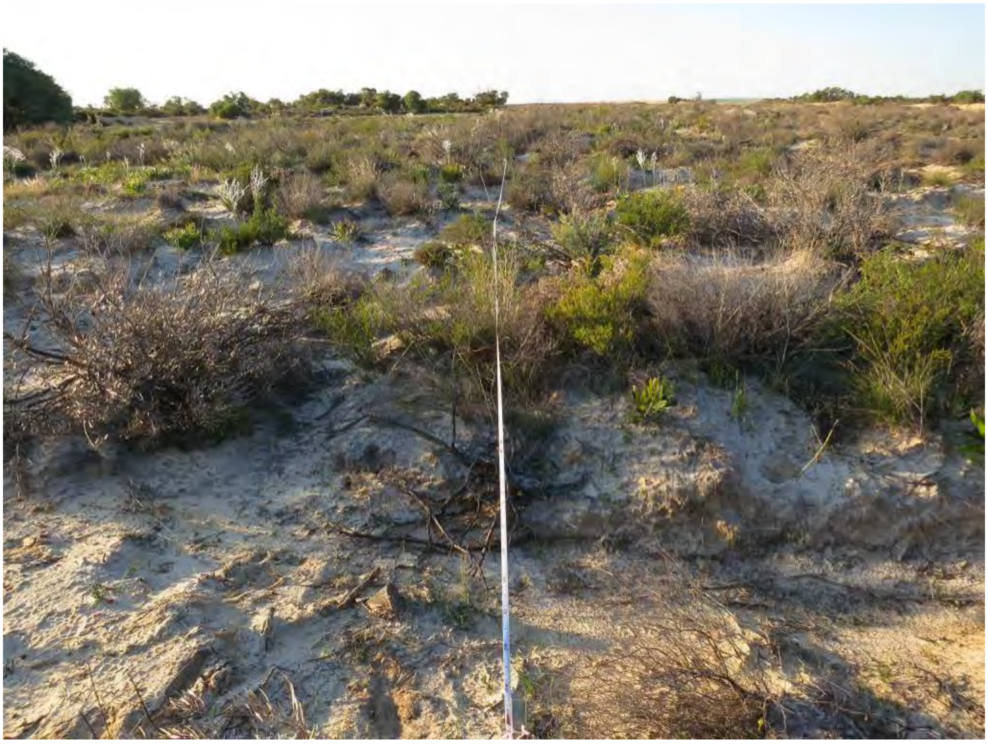
Photograph E155: VDT Treatment 4, Transect 4 START, October 2019



Photograph E156: VDT Treatment 4, Transect 4 END, October 2012



Photograph E157: VDT Treatment 4, Transect 4 END, September 2013



Photograph E158: VDT Treatment 4, Transect 4 END, October 2014

Photograph E159: VDT Treatment 4, Transect 4 END, September 2015

Photograph E160: VDT Treatment 4, Transect 4 END, October 2019

APPENDIX F: SUMMARY OF RESULTS FROM THE VEGETATION DIRECT TRANSFER TRIAL, 2019

Note: +I and -I indicate with and without introduced species respectively

Transect	Transect Start (GDA94_Z50)		Transect Finish (GDA94_Z50)		Mean Alive Plant Density (per m^2)	Mean Dead Plant Density (per m^2)	Mean Alive Foliage Cover (%)	Mean Dead Foliage Cover (%)	Species Richness		Total Species Richness (total spp. per treatment)
									+I	-I	
VDT1-1	333291	6705615	333290	6705605	7.55 ± 1.16	2.17 ± 0.34	9.18 ± 2.09	3.17 ± 0.55	35	30	79
VDT1-2	333300	6705613	333301	6705602	10.17 ± 0.72	1.71 ± 0.22	36.19 ± 4.32	10.57 ± 2.89	50	49	
VDT1-3	333295	6705589	333293	6705577	9.58 ± 1.40	2.17 ± 0.46	35.50 ± 5.12	5.16 ± 3.12	46	45	
VDT1-4	333297	6705551	333297	6705539	11.92 ± 1.93	1.75 ± 0.28	40.54 ± 7.99	3.36 ± 0.88	35	32	
VDT T1 Mean					9.85 ± 0.70	1.96 ± 0.16	30.80 ± 3.14	5.65 ± 1.13	41.50	39.00	
VDT2-1	333312	6705654	333318	6705643	15.08 ± 1.93	1.50 ± 0.29	49.89 ± 9.46	3.44 ± 0.96	39	39	66
VDT2-2	333319	6705633	333311	6705625	24.83 ± 8.48	1.00 ± 0.00	50.84 ± 10.81	2.65 ± 0.88	36	36	
VDT2-3	333310	6705615	333310	6705604	32.58 ± 4.68	1.17 ± 0.12	38.79 ± 7.81	1.38 ± 0.25	43	42	
VDT2-4	333284	6705581	333283	6705593	24.00 ± 5.68	0.00 ± 0.00	54.70 ± 9.71	8.80 ± 2.04	34	32	
VDT T2 Mean					24.13 ± 2.90	1.27 ± 0.09	48.56 ± 4.68	3.49 ± 0.62	38.00	37.25	
VDT3-1	333309	6705641	333300	6705633	15.92 ± 2.73	0.83 ± 0.22	56.56 ± 9.43	5.64 ± 0.82	45	43	81
VDT3-2	333285	6705571	333283	6705558	9.92 ± 3.64	0.00 ± 0.00	85.58 ± 10.08	5.20 ± 1.81	36	35	
VDT3-3	333285	6705551	333286	6705539	12.58 ± 4.01	1.00 ± 0.00	51.37 ± 9.91	6.25 ± 2.17	42	40	
VDT3-4	333309	6705567	333309	6705556	16.00 ± 3.73	2.00 ± 0.50	78.70 ± 8.87	6.74 ± 1.34	46	46	
VDT T3 Mean					13.60 ± 1.76	1.20 ± 0.16	68.05 ± 5.09	6.07 ± 0.75	42.25	41.00	
VDT4-1	333309	6705651	333301	6705643	15.08 ± 2.88	1.00 ± 0.20	51.51 ± 10.92	9.04 ± 3.06	51	50	85
VDT4-2	333309	6705589	333309	6705577	13.50 ± 1.70	2.00 ± 0.29	51.52 ± 8.97	25.59 ± 7.78	43	43	
VDT4-3	333300	6705569	333300	6705559	10.55 ± 1.62	1.50 ± 0.20	63.00 ± 10.08	2.93 ± 0.60	32	32	
VDT4-4	333305	6705543	333308	6705535	39.58 ± 6.00	1.67 ± 0.17	43.60 ± 7.01	8.19 ± 3.43	49	49	
VDT T4 Mean					19.87 ± 2.42	7.50 ± 1.19	52.41 ± 4.64	12.50 ± 2.59	43.75	43.50	