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INTRODUCTION

The following brief overview was prepared to assist in outlining some of the issues for planning rehabilitation needs on the proposed Silica sands operations by VRX Silica.

As a summary of key points it raises some issues that need discussion with the operational team at VRX Silica.

VEGETATION DIRECT TRANSFER (VDT) TRIAL

A rehabilitation technique that was first implemented at Iluka Eneabba in 2012 by the Iluka site personnel. Since this time the Mattiske Consulting team have been assessing the progress of the plants from this method. As such it supplements the extensive rehabilitation practices on the Iluka operations which relies on the more classical approach of site preparation and seeding. Iluka differs from other rehabilitation areas on mining operations in that the native vegetation was also mulched and applied to the rehabilitation areas.

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). The method trialled on the VDT 16 trial Vegetation Direct Transfer transects in 2019.

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).

Primary Aims – to assess:

- . the survivorship of rushes, sedges and herbaceous species.
- . resprouting species.

Key Findings

Flora

130 vascular plant taxa, 66 plant genera, 28 plant families in 2019.

No Threatened species.

5 priority flora (*Comesperma rhadinocarpum*, *Desmocladius elongatus*, *Hemiandra* sp. Eneabba (H. Demarx 3687), *Hypocalymma gardneri* and *Schoenus griffinianus*)

***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-).

***Desmocladius 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-).

5 introduced species.

Species Richness

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.

Native Foliage Cover

Mean alive native foliage cover has markedly increased within all four treatments.

All of the treatments seeing an increase of over double the mean alive native foliage cover recorded during the 2019 monitoring.

Density by Lifeform

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.

Changes

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.

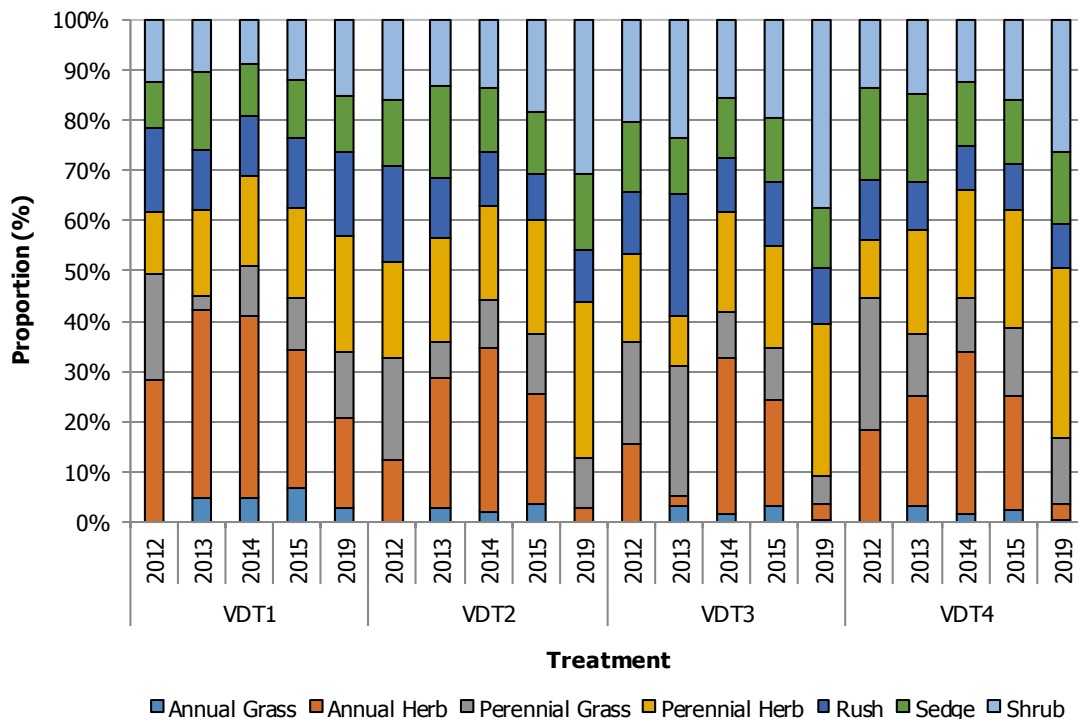
This is encouraging given that recalcitrant (cannot be propagated easily from seed or vegetatively) resprouter species from the families *Cyperaceae* and *Restionaceae* have often been absent in past rehabilitated areas using differing techniques to the Vegetation Direct Transfer trial.

There were generally high numbers of resprouting plants and additional regeneration across the majority of the Vegetation Direct Transfer trial area.

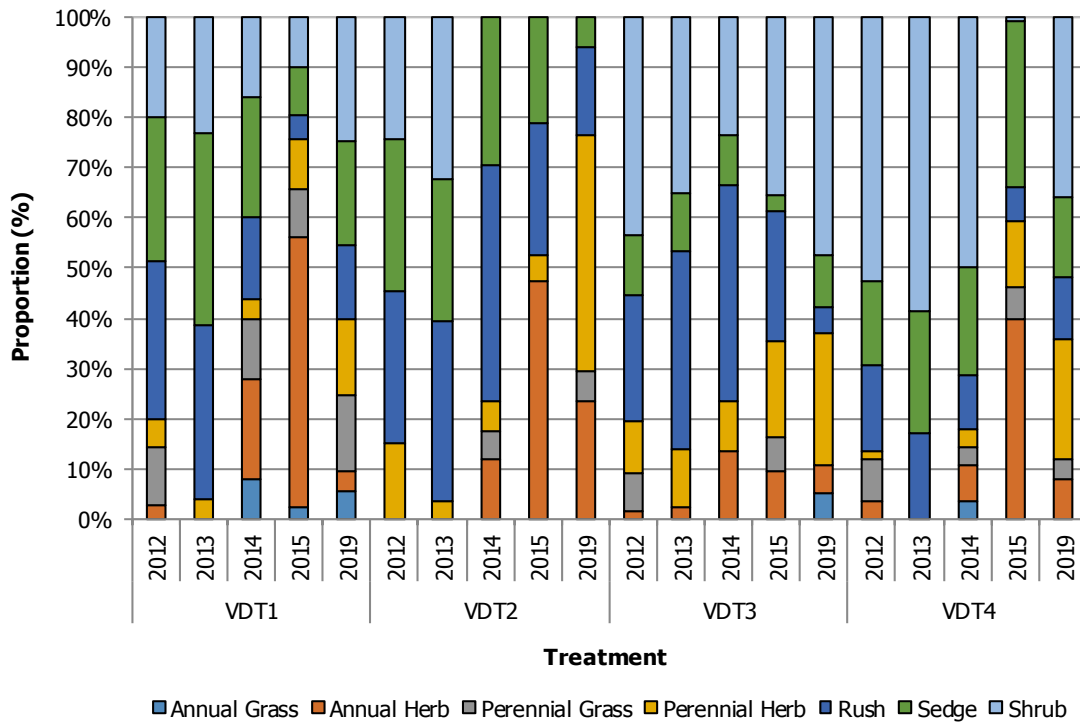
There was an overall increase in foliage cover, shrubs were observed to be resprouting, and in particular, *Adenanthos cygnorum* was noticeably larger than previous monitoring years. The continual presence of the tuberous species such as *Haemodorum* and *Thysanotus* was also observed. Furthermore, an 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.

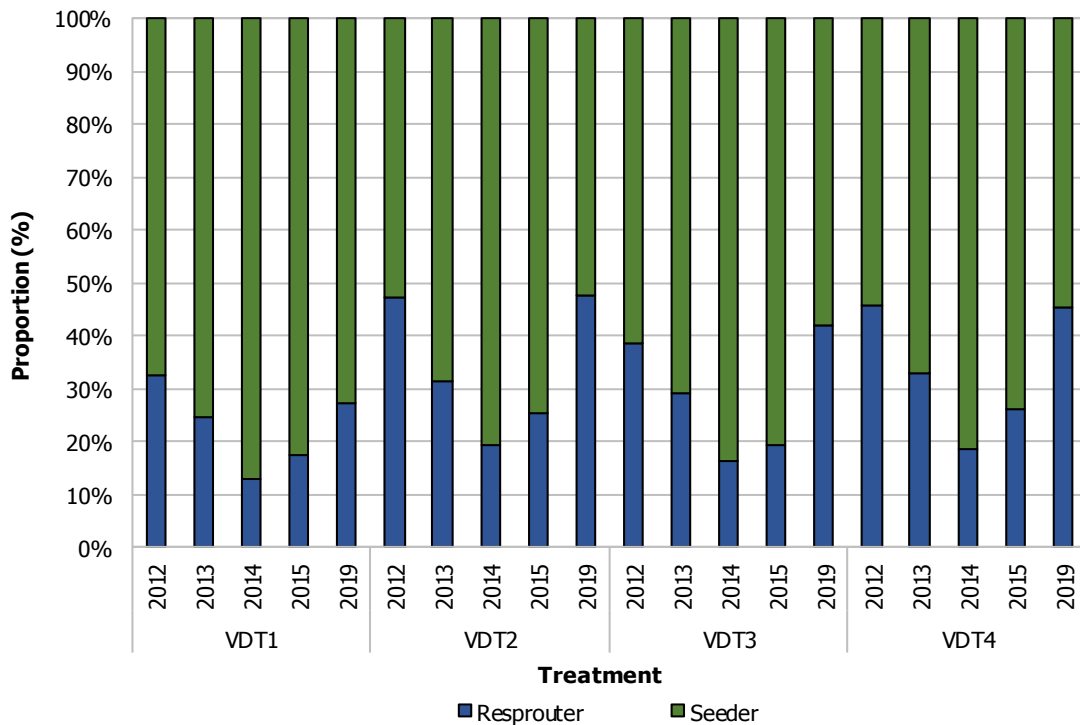
Some key dominant species found in undisturbed kwongan such as *Banksia* and *Petrophile* species are yet to become apparent in the vegetation structure.



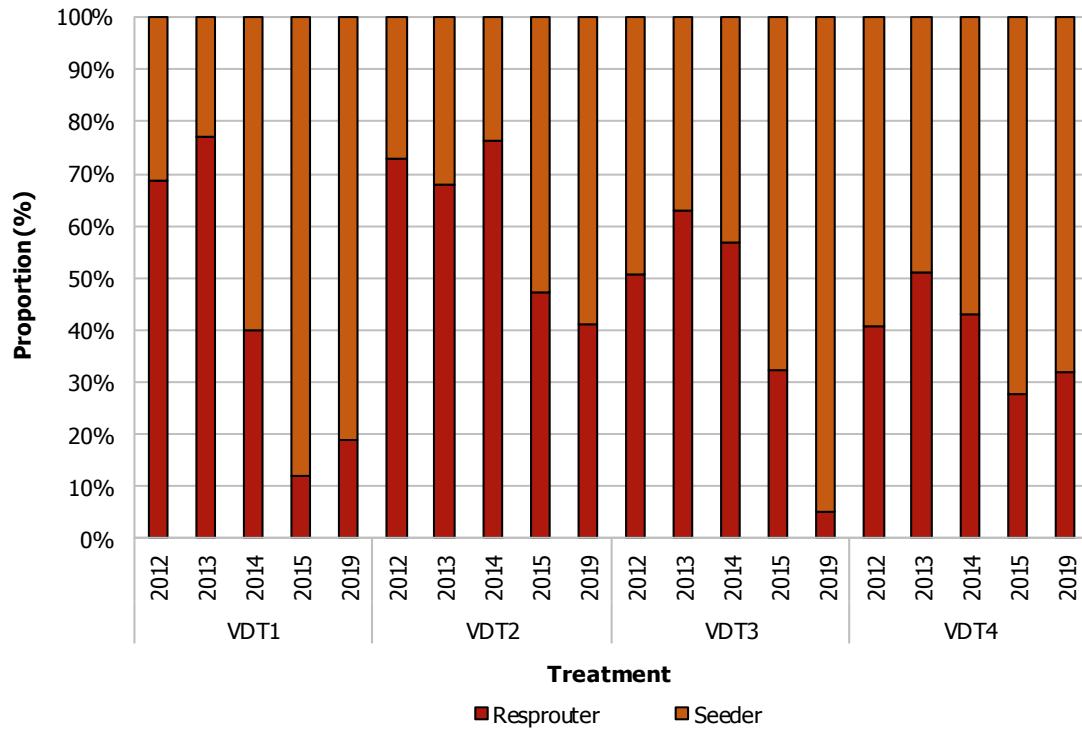
Proportion (%) of alive plants by growth form per VDT treatment during 2012, 2013, 2014, 2015 and 2019



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



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



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

REVIEW OF ROOT STUDIES

Key Findings

Majority of the roots and underground rhizomes and organs occur in the 30cm of soil (see 30cm ruler on Photograph below). The exceptions include some shrub species that send deeper roots to several metres below the surface.



In addition, some of the dominant shrubs and trees have large lignotubers and/or lateral roots and deeper roots. The latter larger lignotubers and roots pose some difficulties in designing mining and rehabilitation methods for the proposed silica sand operations.

The latter larger root or underground organs include species of *Banksia*, *Xylomelum*, *Eucalyptus* and *Macrozamia*. Of the latter the absence of some of these species in the VDT trials reflects the difficult of establishing these species from propagules. To illustrate the latter points a series of photos illustrate some of the challenges faced in the mining and rehabilitation process. Further some of these species may influence and impact on fauna species (e.g. *Banksia* species used regularly for foraging by Cockatoos).

Implications for Mining and Rehabilitation

There were lower numbers of larger trees and shrubs in North Arrowsmith than in Central Arrowsmith. Nevertheless challenges still persist on a range of larger shrubs that have root systems that will need addressing in the planning phase of the mining and rehabilitation phases of the operations.

The examples of the larger root systems are illustrated below. In relation to some species there has been a reliance on transplanting for species such as *Macrozamia fraseri* and from seed for species such as *Eucalyptus*, *Banksia* and *Xylomelum*. As these plants are slower growing the criteria associated with the progress of rehabilitation can be influenced by the species, targets and timeframes.

Macrozamia fraseri – can weigh up to a tonne and be a metre across and over a metre deep



Eucalyptus tottiana – large lignotubers near surface (>30cm) with laterals (10 to 20cm) and droppers (10 to 20cm).



Banksia species – see both lateral and deeper roots – roots extended to at least 3 to 4 metres and although decreasing in size were still substantial within upper soil profiles.



***Xylomelum angustifolium* (Woody Pear)** – large lignotubers near surface (>30cm) with laterals (10 to 20cm) and droppers (10 to 20cm).



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