GETTING THE REVEGETATION FRAMEWORK RIGHT

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The name of this Association is the Revegetation Industry Association. This simply defines what you do, or that revegetation is a by-product of what you do. You are involved in revegetating newly disturbed areas, artificial landscapes, and reconstructed soil profiles, and in all manner of ecological niches. These may include wetlands, damplands, sumplands, landscape units on a slope, the tops of ridges, plateau surfaces, road batters and so on. There are times when you will also be involved in revegetating undisturbed areas.

I have simplified things in this brief paper by addressing those issues associated with revegetating artificial landforms and reconstructed soil profiles, although the general principles hold true for simply revegetating disturbed lands.

The first requirement, before all else, is to understand what it is you are trying to achieve with the revegetation programme and why. If you think you have this clearly sorted out, then have a look at what vegetation is, or was there, prior to disturbance, if you can. This is easy for a greenfields mining site but not so easy in other situations. The next step then is to define where you are in time and space. How old is the upper surface of the land, or the regolith? What was the original geology and how has this been altered over time through weathering and erosion? Are the landforms present a result of climate change? For example, has the onset of aridity directly impacted surface form and process? Or, is the location of the area of interest such that the upper surface is ancient, as in many inland areas of Western Australia. Here, we have scales of time, 15,000 years, as in many areas along the coastal plain, to millions of years, and tens of millions of years inland. So as a first exercise in the revegetation programme, and in both cases, you are dealing with original vegetation communities that have adapted to change. In so doing, they have adapted to a set of physical conditions dominated by geology, landform, soil, and hydrology, as maintained and regulated by present climatic within an envelope of weather extremes. We do not know the envelope of variability within the present climate. It is a question of scale. What is an appropriate scale for addressing this?

Before you start any sort of revegetation programme, spend some time to understand the system or the physical framework that you are going to disturb as in the case of a greenfields mine site, or the system that you are going to revegetate such as a road batter or waste rock dump. If you don't understand the physical framework of the pre-disturbance state, and the component roles of supporting vegetation, then you will never successfully emulate these conditions for your revegetation programme.

It is rather sad, that in this day and age, this concept is poorly understood as is evidenced by those who insist on dominating nature. We can not dominate nature, and can not manufacture nature. But, if we understand the physical framework and the systems in place, then we can, quite legitimately, work with nature.

If we accept this, then we can move forward. All revegetation sites have a physical framework and the first task is to define this framework and its various components, *ie.* geology, parent material, landform, soil, hydrology, and climate. Each of these components directly impacts and influences the behaviour of the system through a complex interaction of feedback loops. Vegetation, the very parameter we are attempting to understand is not only a consequence of the system but also influences the behaviour of the system. It is important to point out that there is no single component of the physical framework that dominates. Understanding the geology is to understand the products of weathering and therefore the resultant parent material, which may be totally different chemically and physically from the original lithology. The landform will directly impact the rate of weathering and the rate of erosion present and the steeper the slope, the greater the energy available for mechanical movement. The characteristics of the resultant soils will mirror their position in space, which will be reflected in their profile complexity. The climate will dictate rainfall patterns, and in particular, the intensity/duration/frequency relationships of rainfall events.

The fate of meteoric input to the soil profile, on the slope or wherever will be dictated in part by the nature of the regolith. So the combined response (performance) of these components is a system that has definable entities. The characteristics of the system can be quantified.

In terms of vegetation, we are particularly interested in the characteristics of the soil profile as these directly reflect its geomorphic pre-history as modified by contemporary climate. Has the profile formed *in situ* or has it formed by the accumulation of eroded sediments. It is useful to give two end-point examples.

At specific locations, the Swan Coastal Plain north of Perth has undergone a very turbulent geomorphic pre-history. For example, a profile situated on a relatively flat area is described as a grey, single grained fabric sand to a depth of 1.9m. At this depth, a hiatus (break in the record) occurs with the sand layer resting on an orange fine sandy clay loam (FSCL) with a clay content of approximately 35%. The top of this orange clay horizon represents the upper surface of an old erosion surface, as the horizon interface is abrupt. The clay layer, which is only 400mm thick, overlies a 600mm thick ferricrete rubble layer, which is stratigraphically discrete, and has very clearly defined upper and lower boundaries. The Fe rubble layer in turn overlies a further orange fine sandy clay loam horizon that continues to a depth of 3.1m below the surface where a second hiatus occurs. At this depth, the FSCL horizon overlies a grey coarse-grained sand in which the clay content is spatially variable but gradually increases with depth to a clayey sand with approximately 3-8% clay) at 4.1m. This profile displays three separate zones, each representing a period in time, and each resulting from a series of specific erosion/deposition systems operating at the time.

At a site in the eastern Kimberly, soil profile characteristics are dictated by the steepness of the slope (natural and undisturbed), high kinetic energy rainfall events, and geomorphic pre-history which includes massive weathering and erosion of hill slope materials to develop a naturally occurring rock mulch. As a consequence of this physical framework, the soils are very shallow, extremely rocky, are best described as chemically and physically barren but still have a distinctive suite of vegetation.

To someone setting out to design and implement a revegetation programme on these areas, it is immediately obvious that each area has its own physical framework and resultant system and each area has its associated vegetation community. So in both cases, the underlying and supporting soils have been derived from parent materials that neither look nor behave like the original geology, and each has a hydrological response to past and present climates.

It would be virtually impossible to faithfully reproduce these profiles in a soil and landform reconstruction programme. But the systems can be emulated if the components are known and the role of each component is understood. In essence, we are interested in the medium that supports vegetation, provides a rooting foundation, a nutrient source, and a source of moisture. So, what do we do, and what do we need to understand.

The second part of this paper looks at a greenfields site as an example in terms of a post-mining revegetation programme. In summary a suggested protocol might be:

- define the pre-disturbance system;
- identify the materials available for reconstruction and characterise them;
- within the available materials, identify those that can best emulate the pre-disturbance system;
- reconstruct the artificial system to emulate the original physical system; and
- identify vegetation species suitable for the new system and if these species mirror the species present in the pre-disturbance system.

The above five bullet points set out the fundamental broad-scale parameters that must be considered if you are serious about understanding the revegetation framework, and then, importantly, getting the framework right.

Define the pre-disturbance system

The following site parameters are key components of the system:

- landform
- surface drainage
- position on the slope
- soil profile characteristics
- moisture retention capabilities
- permeability characteristics
- depth to groundwater
- groundwater quality
- vegetation structure, species present, diversity, etc
- rooting depth

Each of these parameters contains elements that allow a more accurate definition of that particular parameter but such extension is beyond the aims of this paper.

Identify the materials available for reconstruction and characterise them

If this has not been carried out as part of an original soils/soil landscape survey, then it should be carried out in concert with mining personnel and environmental officers. Once materials that are available for use have been identified, characterise them so that a second tier of data is available. Conversely, if a materials characterisation programme is carried out as part of the original soil survey, then the results may dictate what materials are suitable for use in a rehabilitation programme. Material characterisation is now very much a fundamental part of any revegetation programme. Typically, such a programme will include particle size distribution, aggregate stability analysis, aggregate stability chemistry, nutrient status, permeability, surface infiltration rate, plus any other parameter considered important for that site.

Reconstruct the artificial system to emulate the original physical system

Construction of the new system is based on a sound understanding of the pre-disturbance system, particularly in the case of the reconstructed soil profile. It doesn't have to be as complex, It can't be. But, it does have to provide the basic processes present in the original system such as material behaviour, and it must be able to store and transport water. The depth below the surface at which this happens is simply a function of how the original profile was formed and operated.

Take an example. An original profile was a deep (2m) medium- to coarse-grained sand, free draining, poor moisture retention, low dry density ratios, but had high surface infiltration rates, and was resistant to surface runoff because of high particle detachment thresholds, and carried Banksia Woodland as the vegetation community. You would not reconstruct the profile to have 0.5m of similar sand overlying a clay-rich (>25% <2μm) horizon and expect the same vegetation community to survive. If you had to reconstruct the profile with these characteristics, you would modify your species to reflect the changed profile and physical system.

Identify vegetation species suitable for the new system and if these species mirror the species present in the pre-disturbance system

Don't forget that the vegetation communities present in the undisturbed system are both a part of that system while contributing to the dynamics of the system. You have to be prepared to compromise. That goes for everyone.

Can you legitimately expect everything you plant into the new system to grow? If not why not?

If you don't expect some species included in the seed mix to grow, why plant them! Should you have a 'staggered' approach to seeding and revegetation? Is there a 'preferred time' for reintroducing certain species into a revegetation programme. Now, if you think you understand all this, add the uncertainty of our envelope of climatic variability, more specifically, the envelope of rainfall variability.

A basic question to be asked is "when it rains, how much of the profile gets wet'? How much rain do we need to wet the full depth of the profile? How will my brand new vegetation growth handle lack of rain when it is supposed to be raining?

As people responsible for assessing undisturbed vegetation communities, recommending seed mixes, and assessing revegetation efforts as an ongoing component of rehabilitation programmes, it is quite legitimate for you to ask for a description of the system, either pre-disturbance or reconstructed, or both. You should not be afraid to relate the two systems and to identify the main system components. And you should not be reticent to point out to all and sundry that the reconstructed system is nothing like the original system, if this is indeed the case.

While all this sounds a bit complex, and perhaps confusing, it is simply proper planning. I would hope that in the 21^{st} century, planning for rehabilitation success would include, by implication, planning for revegetation success. Understanding the system is simply part of the planning process.

The great leveller in all this is that no one puts a temporal scale on rehabilitation success. The reason? No body knows, and so that puts greater pressure on us as revegetation practitioners to get it right at the planning and then implementation stage.

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