Monitoring with purpose – linking to completion

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Outback Ecology

Why we monitor

- Monitoring is a valuable source of scientific information
  - What went well, what didn't, how can we improve
  - Applies to any revegetation or rehabilitation effort, from farmland to mined land
  - Is certainly the case in mining rehabilitation at long-lived operations, where there is clear value in learning from past-performance, to fine-tune future strategies

Why we monitor (cont.)

- Monitoring for relinquishment
  - Ultimately used in a decision on transferring responsibility for the land
  - There is a point in time for all mines, where companies wish to relinquish
  - In the mining industry, this responsibility is typically accepted by the State
  - Monitoring then becomes critical to inform of acceptability of the revegetation outcome, and to assess the risk of ‘failure’ in the future
  - Relinquishment is not yet common

Discriminating between ‘acceptable’ and ‘unacceptable’

Source: Tongway *et al*, 2004

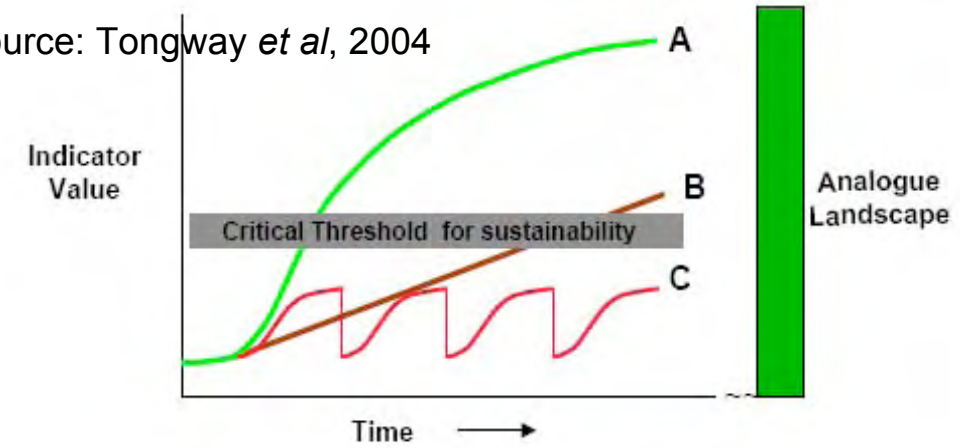


Figure 43. Three contrasting ecosystem rehabilitation trajectories.

Completion or Performance Criteria

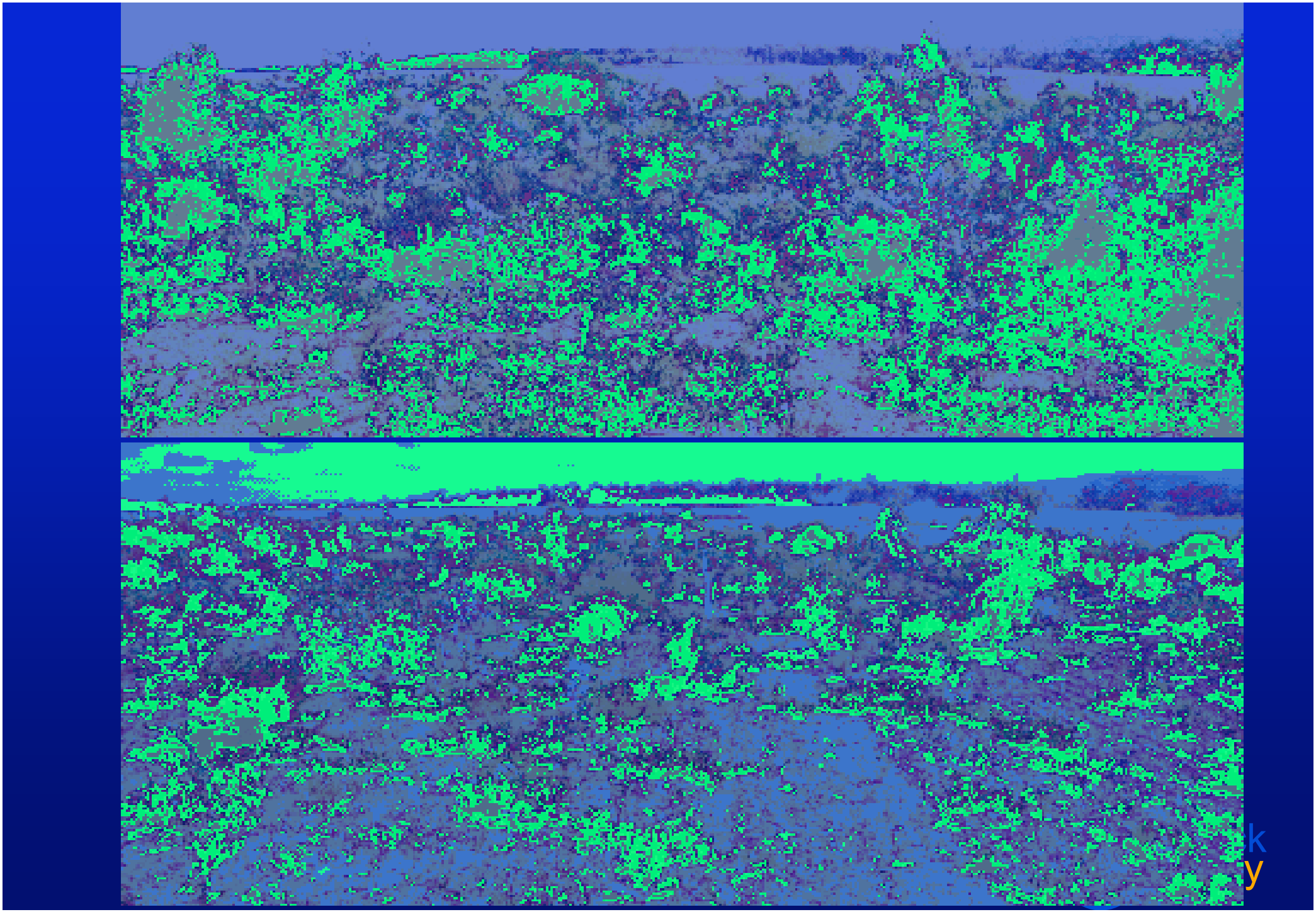
- It is essential that ‘what is acceptable’ is defined and understood, before relinquishment is requested - ideally before revegetation commences.
- Prior agreement on end land use is implied
- Appropriate criteria need to be discussed and agreed with all stakeholders
- Will reflect the commitments and policies of the company and its shareholders, together with those of regulators and other stakeholders

EPA Guidance No. 6

- Proposed standard objectives for rehabilitation
  - safe, stable and resilient landforms and soils
  - appropriate hydrology
  - providing visual amenity, retaining heritage values and suitable for agreed land uses
  - resilient and self-sustaining vegetation comprised of local provenance species
  - reaching agreed numeric targets for vegetation recovery; and
  - comprising habitats capable of supporting all types of biodiversity
- Starts with the abiotic, through to the biotic

Context

- Mining operations occur in a diversity of landscapes, ecosystems and end land uses
- Ecosystems: complex, long-term development
- Mine closure occurs over a relatively short time
- Various tools may provide evidence, but must be robust and scientifically-valid
- Completion criteria
  - can be based on generic principles but must have locally-specific quantitative standards



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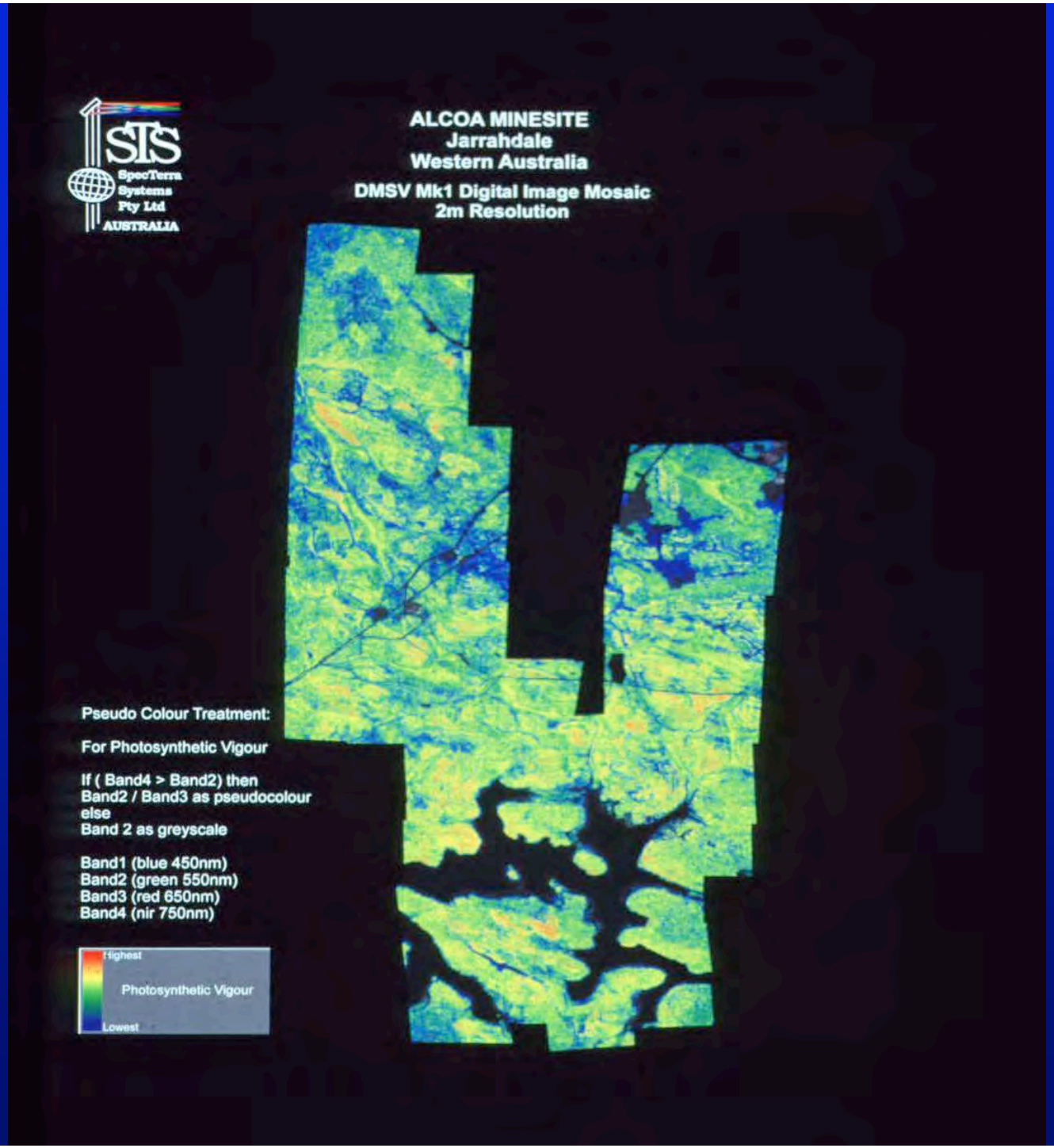
Aspects to consider

- Safety and geotechnical stability
- Containment of potentially-hostile wastes
- Groundwater
- Surface hydrology
- Surface stability and erosion
- Ecosystem values and function
- Suitability for on-going management

Some possible indicators of satisfactory progress in rehabilitation

- Soil stability / erodibility
- Infiltration and hydraulic conductivity
- Water run-off quality
- Numbers, cover, spp richness of appropriate plant species
- Available and mineralisable N, P
- Soil organic carbon
- Symbiotic micro-organisms
- Microbial C and respiration
- Litterfall and rate of breakdown
- Invertebrates (eg. collembola, ants,. . .)
- Pathogens
- Plant reproductive capacity / resilience (ie capacity to survive, re-group or re-establish after fire, drought etc; includes soil seed banks)
- Vertebrates



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Relative changes in vegetation and soil biological parameters with increasing age of bauxite mine revegetation

(Y. Sawada, S. Ward, E. Gaunt, D. Jasper (1998))

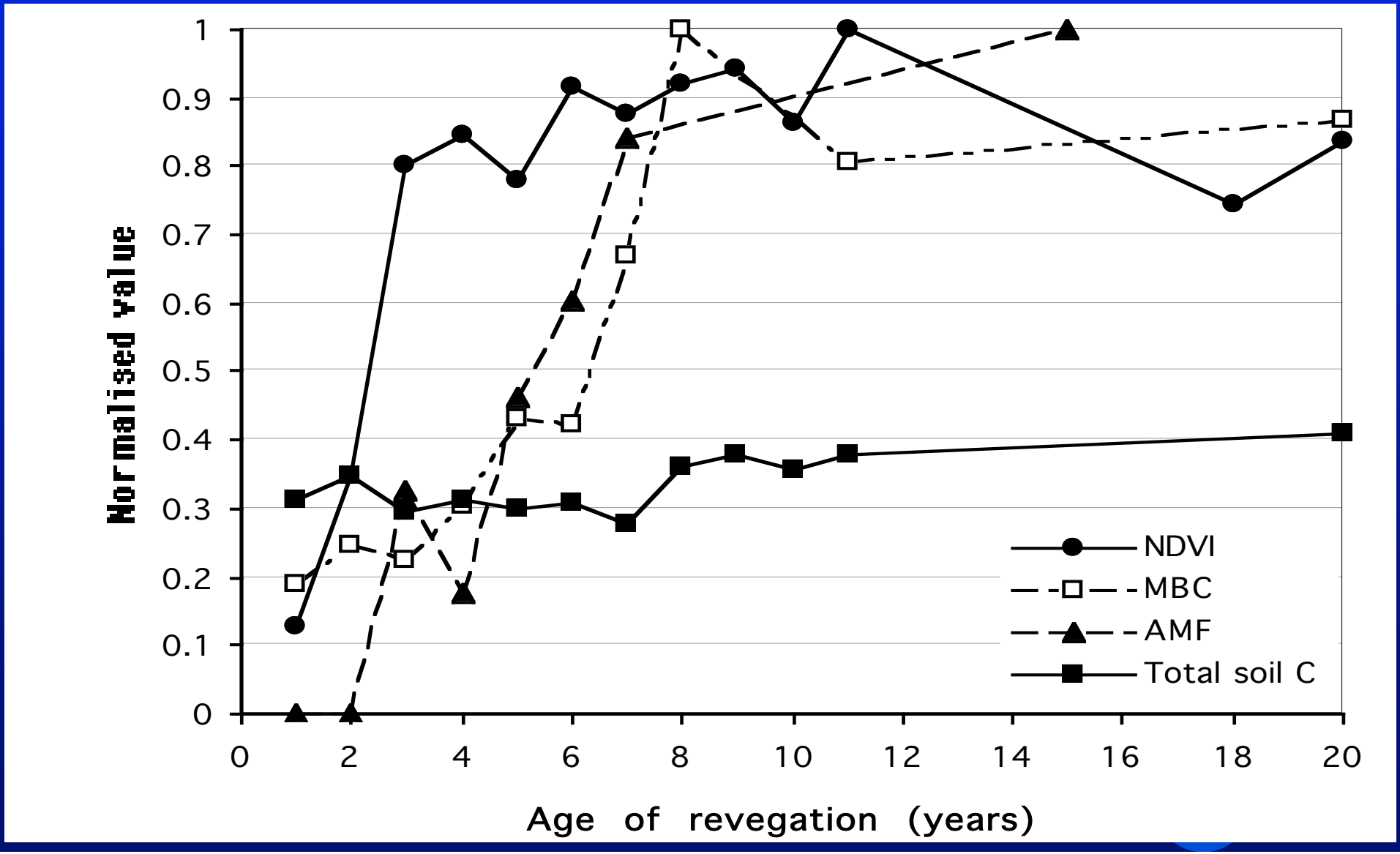

Figure 5b. Spinifex grassland showing good resource control.

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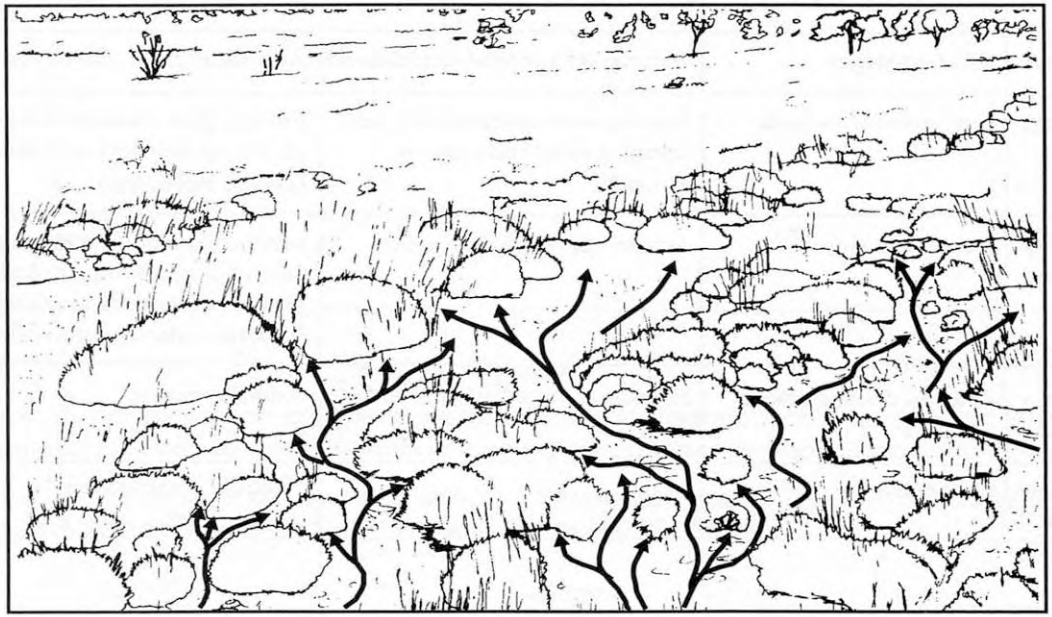

Retention of resources is critical to long-term performance of vegetation in rehabilitated ecosystems

Bank and trough structure on a ripped waste dump

Obstructions to water flow

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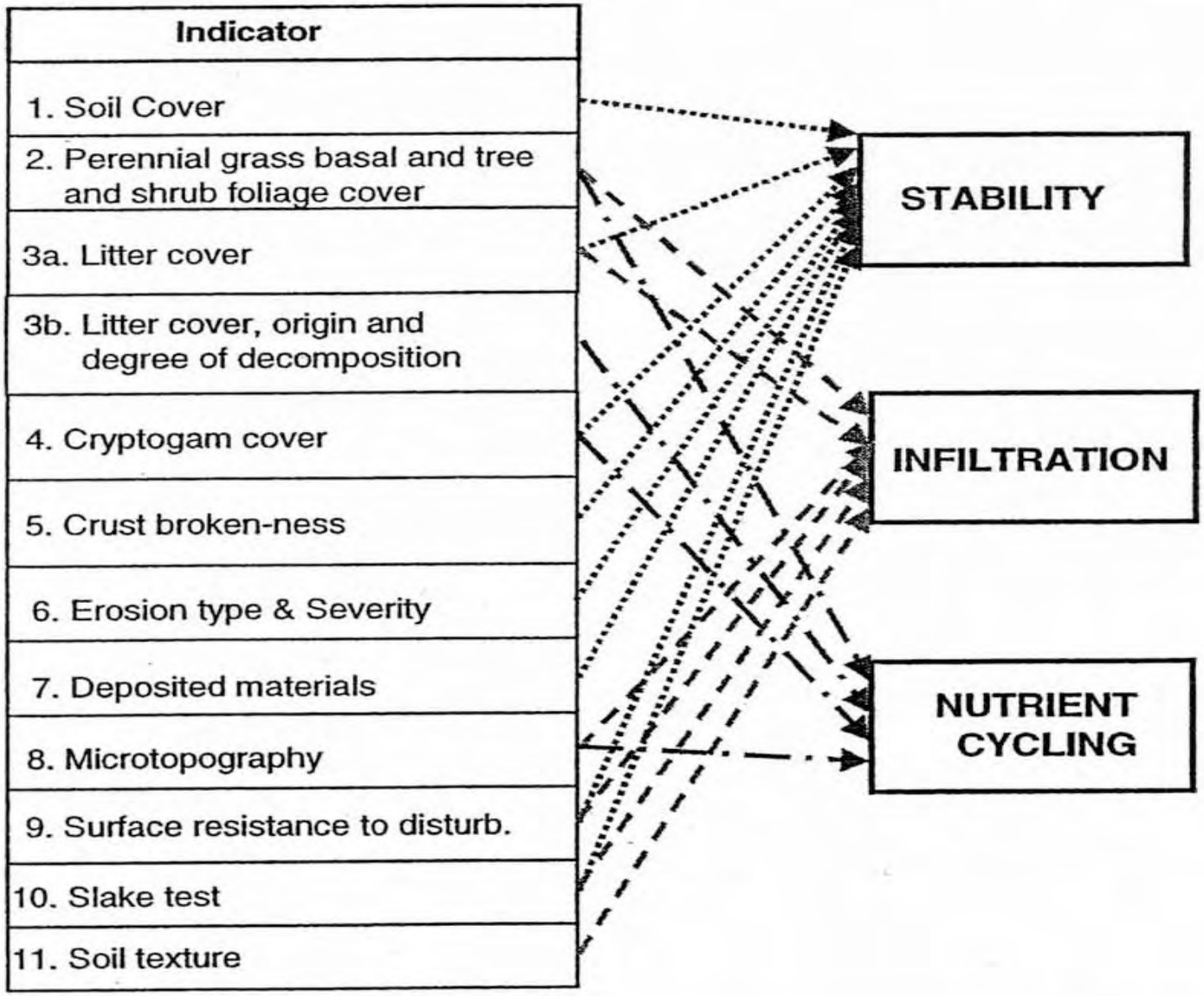
Protection of soil surface and resistance to erosion

Protection of the soil surface by foliage and litter



10. The combination of Soil Surface Condition Classes to derive indices of Stability, Infiltration and Nutrient Cycling

(D. Tongway, CSIRO)

Aspects to consider

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- Ecosystem values and function
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Research to support criteria establishment

- Correlating fauna use with botanical monitoring and LFA
- Soil properties with LFA
  - Selected areas (already monitored using LFA) were tested for physical, chemical and biological soil parameters, using similar methods of comparison adopted by Tongway *et al* (2003).
  - Field and laboratory-based soil measurements included :
    - Infiltration (unsaturated),
    - Soil bulk density,
    - Soil strength (penetration resistance and modulus of rupture),
    - Soil structure and structural stability,
    - Microbial activity (microbial biomass and respiration),
    - Total and plant-available nutrients and soil organic matter.

Other aspects

- Visual amenity / aesthetics
- Resilience (fire, drought)
- Successful reproduction
- Heavy metals
- Fauna

Fauna

- Fauna are important for :
  - Nutrient cycling
  - Pollination
  - Food source
  - Predation
  - Conservation
- Fauna monitoring can only be done late in monitoring sequence - suggest using soil and vegetation as ‘indicators’
- In some cases, fauna may be a critical aspect and should be measured directly

Discriminating between 'acceptable' and 'unacceptable'

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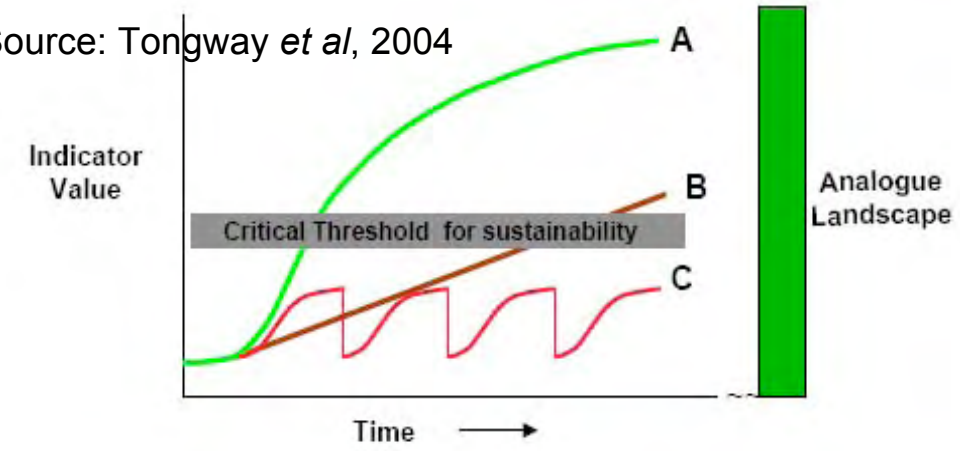
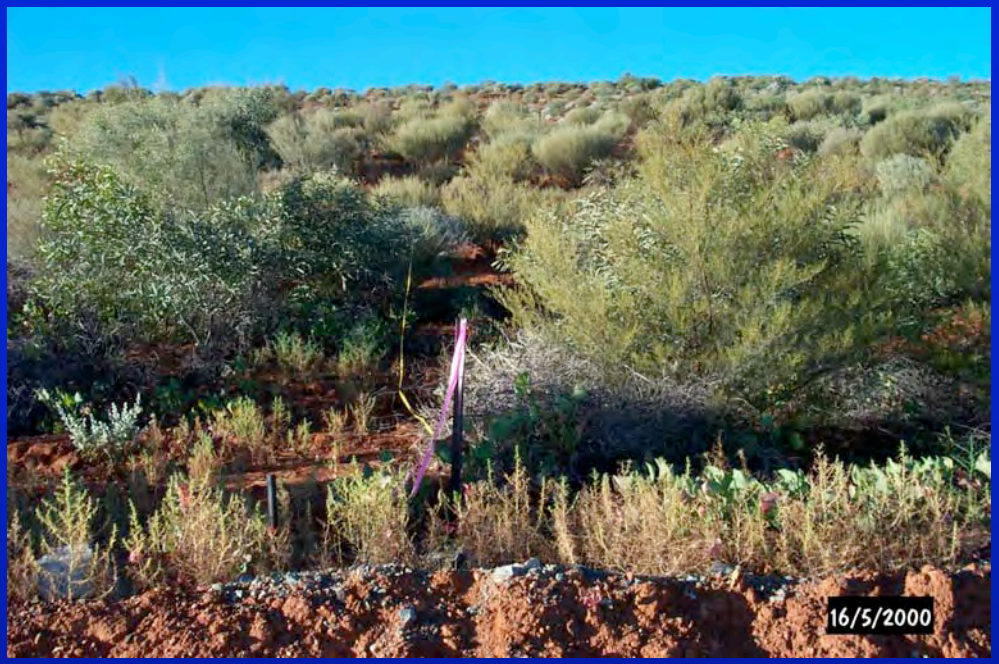


Figure 43. Three contrasting ecosystem rehabilitation trajectories.



Meeting the challenge of integrating the data

• Stability index	58	60
• Infiltration Index	37	43
• Nutrient cycling index	19	22
• Erosion	15%	35%
• Plant density	28,000	7,000
• Plant cover	32%	72%
• Plant species diversity	6 spp.	2 spp.

Rehabilitation Classification®

- Aims to further simplify several years of EFA data – converts multiple indices into a single number
- Assessment of each site's EFA indices
  - Compare with regional data set
  - Change over time, with focus on key indicators of success/failure
  - Trend in scores over time compared to regional analogues
- Emphasizes critical criteria (stability, erosion, plant cover) for bond reconciliation

Rehabilitation Classification®

Categories for Bond Reconciliation (adapted from DoIR, 2003)

Stage	Action	Completion Criteria Met
0	No earthworks completed	No criteria
1	**Primary Earthworks** -Reshaping -Drainage	**Structure stable** **Erosion controlled** Water run-off managed effectively
2	**Finishing Earthworks** -Topsoil spread -Deep ripping	Appropriate topsoil cover Adequate contour ripping **Demonstrated stability and erosion control**
3	**Revegetation** -Seeding -Planting	**Vegetation established** but not demonstrated to be self-sustaining Weed control program commenced Grazing control commenced
4	**Relinquishment** All actions complete	All criteria met

Case Studies

- One Pilbara and one Goldfields mine
- Both sites have
  - rehabilitation on waste landforms ranging from one year old to fifteen years old
  - at least three years of EFA monitoring data
- A variety of rehabilitation techniques and materials were used at each site

Data interpretation

Recommendation: Reduce or discontinue monitoring

Data Interpretation

Recommendation: Investigate constraints before re-assessing

Summary

- Identifying ‘performance criteria’ followed by targeted monitoring, is critical in assessing rehabilitation ecosystem development, particularly in short time frames
- Criteria should be aligned with and relevant to stakeholder expectations at each operation
- There can be value in integrating diverse measures to develop an overview of the rehabilitation
- Appropriate soil properties, vegetation productivity and resource retention are key elements of any suite of criteria