2015 Joint Conference ASMR and ARRI

Reclamation Opportunities for a Sustainable Future

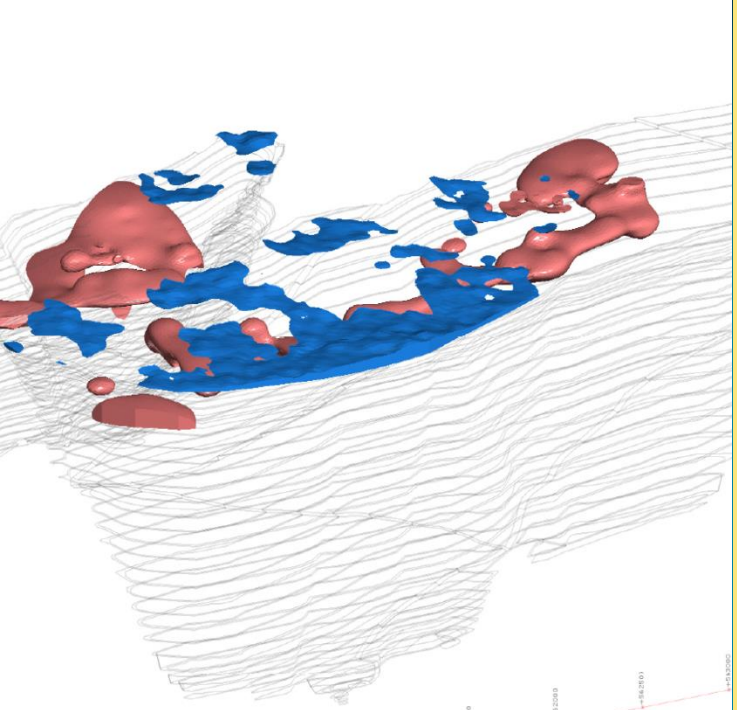
ONE STEP FORWARD – TWO (SIDEWAYS) BACK: EVALUATING AND MEASURING ECOSYSTEM FUNCTION AND COMPLETION CRITERIA IN MINE REHABILITATION[1]

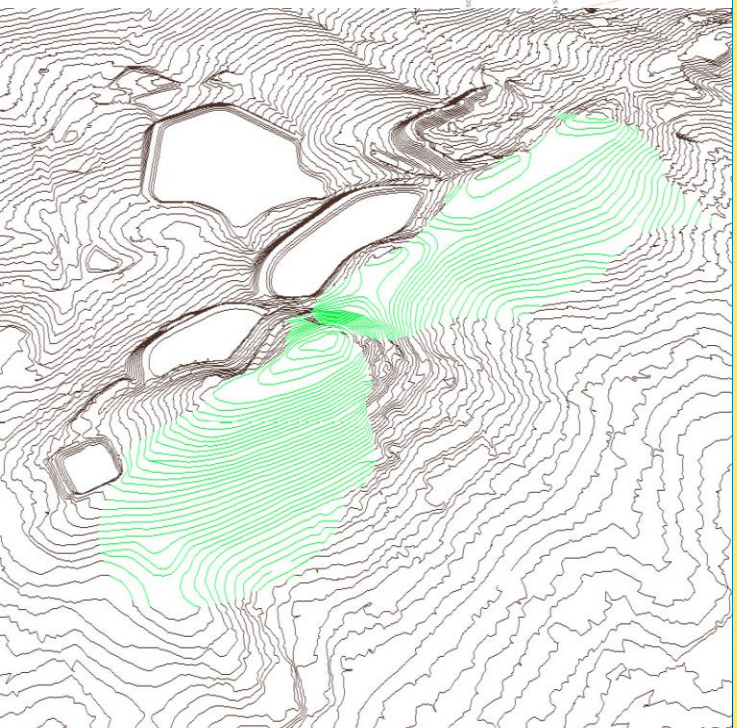
HARLEY LACY

MWH®

Introduction

- Where we as a group are involved in measuring and assessing the progress of restoration and rehabilitation
- What we often choose to monitoring a range of parameters related to the biophysical functioning of the landscape
- The evolution of monitoring tools and the process in selection of integrated monitoring toolbox
- Conclusion .





Soil and Landforms

MWH offers an integrated service for assessment of soil, mine waste and tailings (physical, chemical and geochemical).

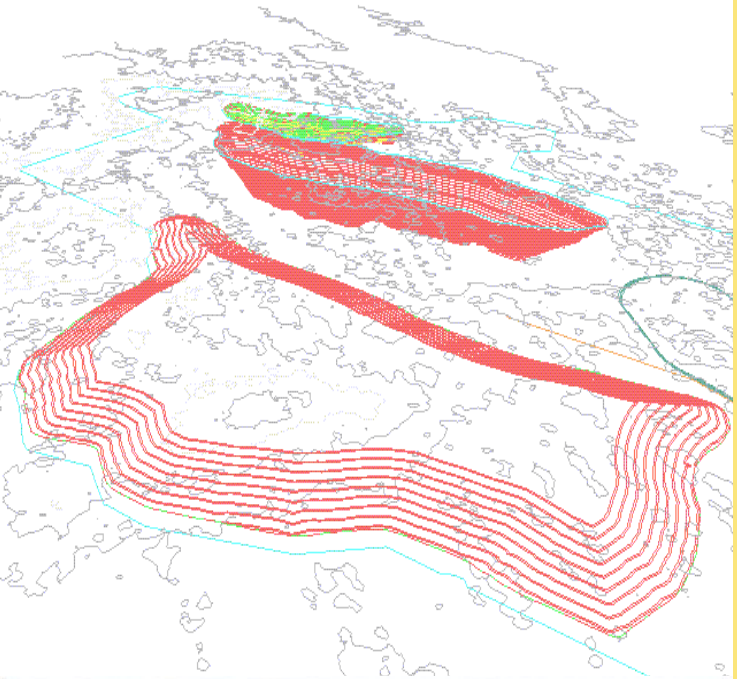
- *development of soil and mine waste material inventories (dynamic through mine life), quantifying the characteristics and volumes of materials*
- *modelling of potentially **hostile** waste materials, and potentially **useful** materials using Leapfrog*
- *landform design using tools including Autocad, Dumpsolver Carlson, incorporating :*
  - *waste material characteristics and volumes,*
  - *surface water management,*
  - *management of potentially hostile materials,*
  - *rehabilitation planning, and*
  - *post construction monitoring*
- *placing the materials in the appropriate place the first time, reducing double handling and identifying the cost savings to be made*

Rehabilitation Monitoring

- *Variety of methods, including EFA*
- *Identify issues early and demonstrate changes over time*
- *Evaluate rehabilitation against completion criteria targets*
- *Analogues used to set completion criteria*
- *Closure monitoring plans*

Completion Criteria

- *Specific values to be achieved (e.g. LFA, erosion, vegetation)*
- *Criteria targets should be SMART*
- *Selecting appropriate analogues*
- *Achievement of criteria leads to relinquishment of bonds or reduction in legal liability and toward relinquishment*



Closure Planning

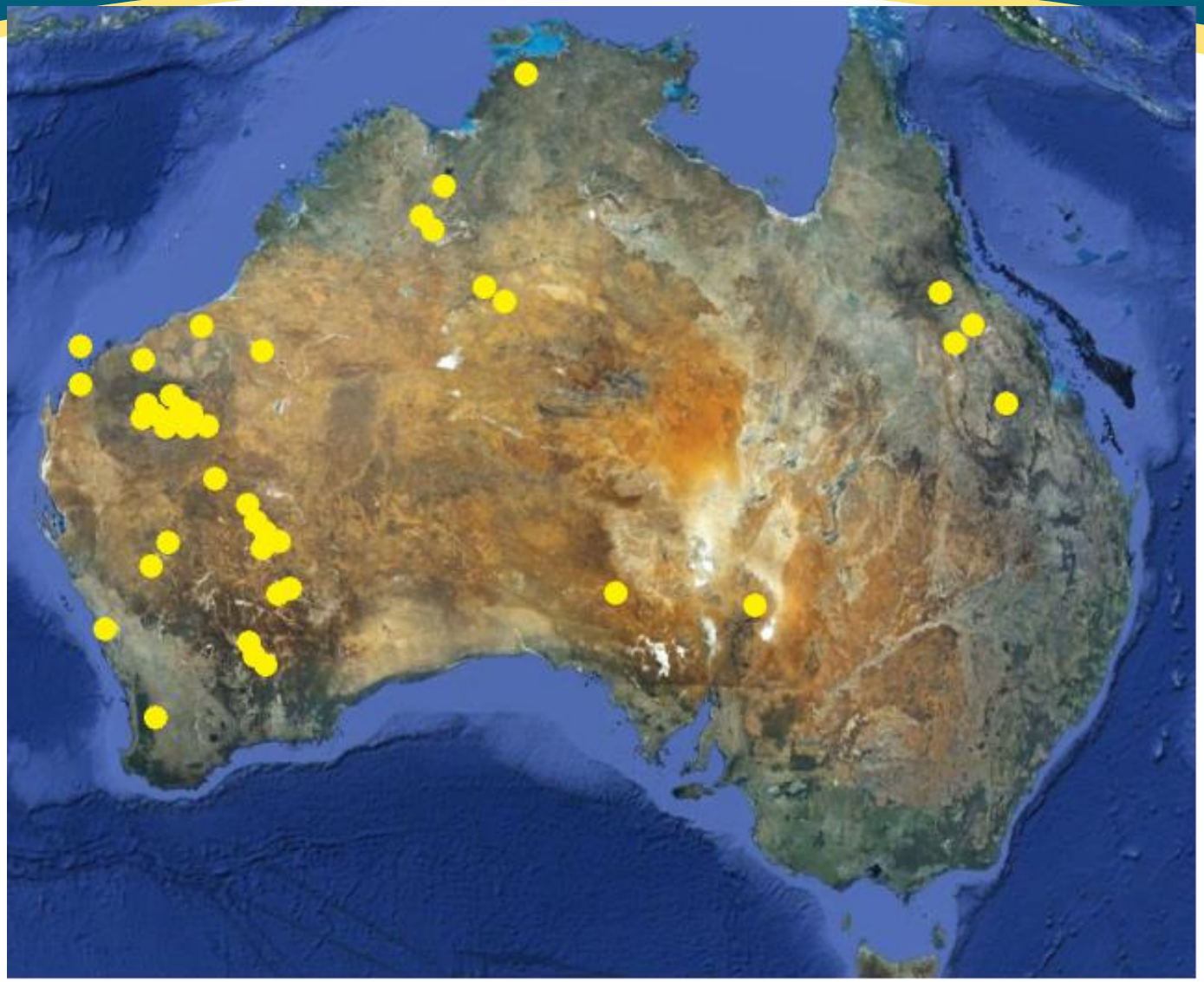
MWH has significant experience in the reclamation of mining and mineral processing operations

- *Cost efficient closure planning solutions*
  - *"Right material in the right place for the least cost".*
  - *Applicable to TSFs, landforms, pits, contaminated site remediation and infrastructure. Supplemented through the use of MWH landform solutions tools*
- *TSF Decommissioning and Rehabilitation Plans*
- *WRL Decommissioning and Rehabilitation Plans*
- *Closure materials balance and mapping*
- *Financial provisioning*
- *Stakeholder Consultation*

Setting the scene

- Outback Ecology 75 people, my time in industry (and my Rangeland - Ag science, and exposure to CSIRO)
- 1989 - 10 years of vegetation transect monitoring (mine waste), with applied soil science to conduct 10 tailings trials (8 years)
- Revegetation on Mine waste, botanical data, unable to determine success and unpredictable.
- We needed to assess the edaphic factors of mine reclamation, the industry need a tool to understand landscape and ecosystem function.

Here there and every where



Influences that drive selection of the appropriate tools for measuring completion criteria

MINING

- Mining causes a high level of disturbance to ecosystems.
- The ecosystem may never totally recover from these activities.
- Disturbed sites have the potential to become ‘new ecosystems’ that can’t easily be described other than in terms of reclamation / rehabilitation based on terms and values that are physically stable and bio geochemically relative to existing nearly ecosystems.

The Mine Business and Regulators like certainty

- Key Performance Indicators
- Original EIA Defines Closure Targets and "Principal Risks"
- Establishing closure KPI gateways
- Establish process to deliver KPI's
- Procedure based
- Systematic, measured and evaluates closure.

A need to understand the full function; USA

- **RELATING MINELAND RECLAMATION TO ECOSYSTEM RESTORATION** (Stahl[2], Ingram, Wick and Rana, 2006 Billings)
- Normal definitions of restoration are impractical because some ecosystem components cannot be returned to exact pre-disturbance condition
- While devoting attention to ecosystem functions, the ecosystem restoration approach (SER, 2004) acknowledges that measurement of most ecosystem functions is beyond the capabilities and budgets of most restoration projects and these functions must be assessed indirectly
- Most scientists have come to realize, however, that vegetation indicators alone do not provide sufficient information to properly evaluate ecosystem function or sustainability and must be used cautiously (Blum and Santelises, 1994; NRC, 1994; Larson and Pierce, 1994; Karlen et al., 1997).

- **AGGREGATE SIZE DISTRIBUTION AND STABILITY UNDER A COOL SEASON GRASS COMMUNITY CHRONOSEQUENCE ON RECLAIMED COAL MINE LANDS IN WYOMING[1]**
- A. F. Wick[2], P. D. Stahl, L. J. Ingram, G. E. Schuman, and G. F. Vance 2006 Billings
- Inadequate recovery of soil structure and function can lead to future site degradation because plant community productivity and diversity are highly dependent upon soil physical, chemical and biological properties (National Research Council, 1994).
- Soil structural recovery in drastically disturbed lands is important for ecosystem function and reclamation success.

A need to understand the full function; USA

- **INTEGRATED RECLAMATION: APPROACHING ECOLOGICAL FUNCTION?**
- Ann L. Hild2, Nancy L. Shaw, Ginger B. Paige and Mary I. Williams (Billings 2009)
- Research should assist managers with integrating spatial and temporal variability of ecosystem processes into long-term management planning. Using an integrated approach, we can more fully comprehend reclamation within the context of ecosystem function
- **ECOSYSTEM RECOVERY ON RECLAIMED SURFACE MINELANDS**
- P.D. Stahl2, A.F. Wick, S. Dangi, V. Regula, L.J. Ingram, and D.L. Mummey (Billings 2009)
- Study ecosystem structure (e.g. organisms, soils, mycorrhiza) and function (e.g. biomass production, carbon cycling, nitrogen cycling). Chronosequences of reclaimed sites indicate increasing productivity through time in all groups of organisms monitored (plants, bacteria, fungi, nematodes and arthropods) as well as increasing concentrations of soil organic matter, rapid incorporation of organic carbon into soil aggregates, redevelopment of mycorrhizae, and reformation of carbon and nitrogen pools.
- Although the precise trajectory of the restored ecosystems are very difficult to predict because of changing control variables such as potential biota (invasive species) and climate, our data indicates ecosystem structure and function is recovering on reclaimed surface minelands. Tools of 1977 – no available easy of monitoring – vastly improved today

Landscape Function; AUST 2010

- **A review of landscape rehabilitation frameworks in ecosystem engineering for mine closure. International Mine Closure 2010** **Drake, J.A., Greene, R.S.B., Macdonald, B.C.T., Field, J.B. & Pearson, G.L. (2010).**
- *In ecosystem design there should be consideration of the four key dimensions of any ecosystem; landscape, function, structure and composition (LFSC).*
- As engineered ecosystems have no specific reference ecosystem to use in the design process, recreating complexity of a system with no baseline can be problematic. Problems occur in the design, implementation and determining the end point of the ecosystem. This is due to the lack of a reference condition in which rehabilitated conditions can be compared.
- Current rehabilitation frameworks and methods do not always consider the establishment and design of an engineered ecosystem. Frameworks should consider ecosystem complexity and significant changes to the environment as a result of mining practices. Key features of ecosystems include Landscape, Function, Structure and Composition (LFSC). These four key features can be found in any ecosystem, and are independent of environment.
- Monitoring and evaluation through use of the framework is critical in understanding the success of rehabilitation. This allows for adaptive management and drives rehabilitation success.

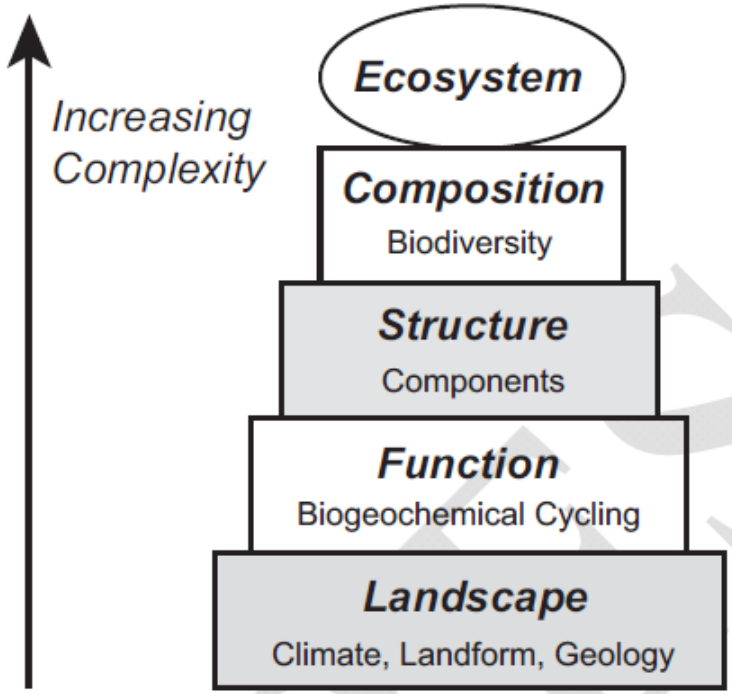


Figure 2 LFSC building blocks for increasing complexity and a self-sustaining and resilient ecosystem (Elmqvist *et al.* 2003; Ruiz-Jaen and Aide 2005; Tongway 2005; Tongway and Hindley 2004)

Landscape Function; AUST 2014

- **Can 'Novel' Ecosystems Offer Suitable Rehabilitation Alternatives for Post-Mined Landscapes?** P Audet1, D Doley2 and D R Mulligan3

- Rehabilitation techniques for highly impacted disturbances− such as those introduced through mining − should then provide a platform for the development of criteria that will sustainability (Grumbine, 1994; Hobbs and Norton, 1996; McCool and Stankey, 2004; Slocombe, 1998; Wallace) encompassing not just the environmental goals but equally those relating to social and economic factors

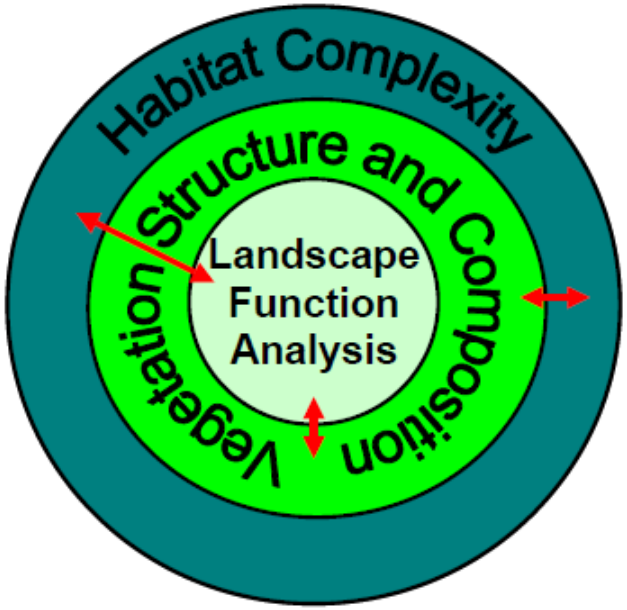
- "The objective analysis of the physical and biological conditions associated with the vegetation associations that are found on the original landscapes could be used for predicting conditions that are most likely to be sustainable on reconstructed landscapes."

Ecosystem Function Analysis (EFA)

- Commonly used throughout the Australian mining industry, and internationally

- LFA development by CSIRO began over 35 years ago (40 Scientists)

- EFA consists of
  - LFA + vegetation + erosion + habitat assessments



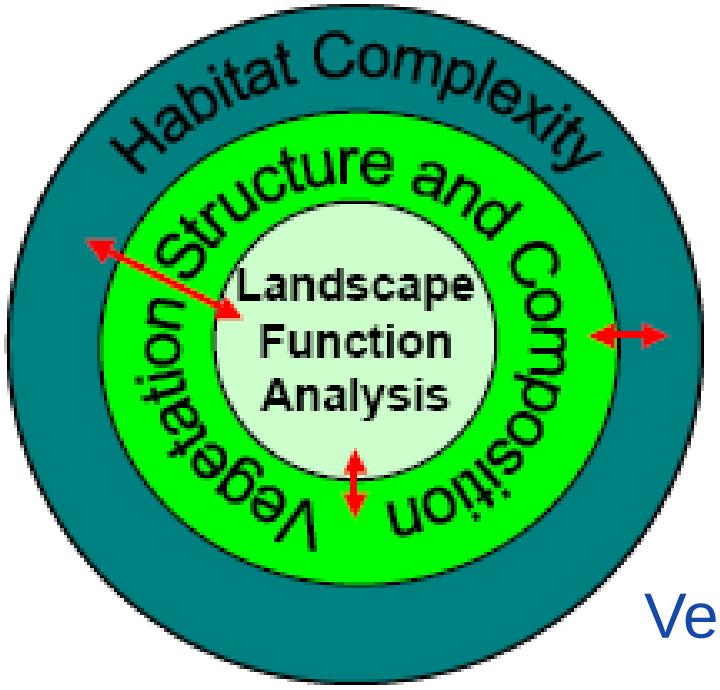
Source: Tongway and Hindley 2004

Ecosystem Function Analysis

Soil stability

Soil infiltration

Nutrient cycling



Rill assessment

Habitat complexity

Vegetation assessment cover , density, diversity, weeds and structure.

Tongway and Hindley, CSIRO 2004

The Role of LFA

LFA and its components have been tested widely

- Australian Minerals Industry
  - 2 stage study undertaken by CSIRO for (ACMER)
  - Correlated with soil procedures (5 Years of work)
  - Spatially extensive data set at a low cost
  - Effective over a wide range of environments
- Regulatory Sign off
  - Bottle Creek WA, Timbarra NSW, and Bonds reduced at many Aust. sites.
- Overseas
  - Africa - Game Parks and Mining Industry
  - Mediterranean regions of Europe

Conceptual Stages in ecosystem development, presented to the MCA in 1997

Landscape function character

Stages

Niche habitats
Processes survive disturbance challenges
Predictable future trajectory

ULTIMATE GOAL

Biological and Functional Diversity, Resilience

“Framework” processes developed
Biological “resource control” established. Increasing complexity

INTERMEDIATE ECOSYSTEM STAGE

Sustainability

Infiltration increasing, runoff decreasing. Low erosion.
Aerial and ground cover increasing
Appropriate species establish.
Physical “resource control”.

EARLY ECOSYSTEM EST. STAGE

Stability

Appropriate physical runoff
-runon character.
-Water storage in soil
.

GEOTECHNICAL STAGE
Land-forming, topsoil management, ARD
Salinity, Water table, Final land-use decision

Foundation

In the real world, the boundaries between stages would be gradual

Data output from field monitoring

Landscape Function Analysis
- Stability Index
- Infiltration Index
- Nutrient Cycling Index
- Proportional zone contributions
- ‘Patch’ area

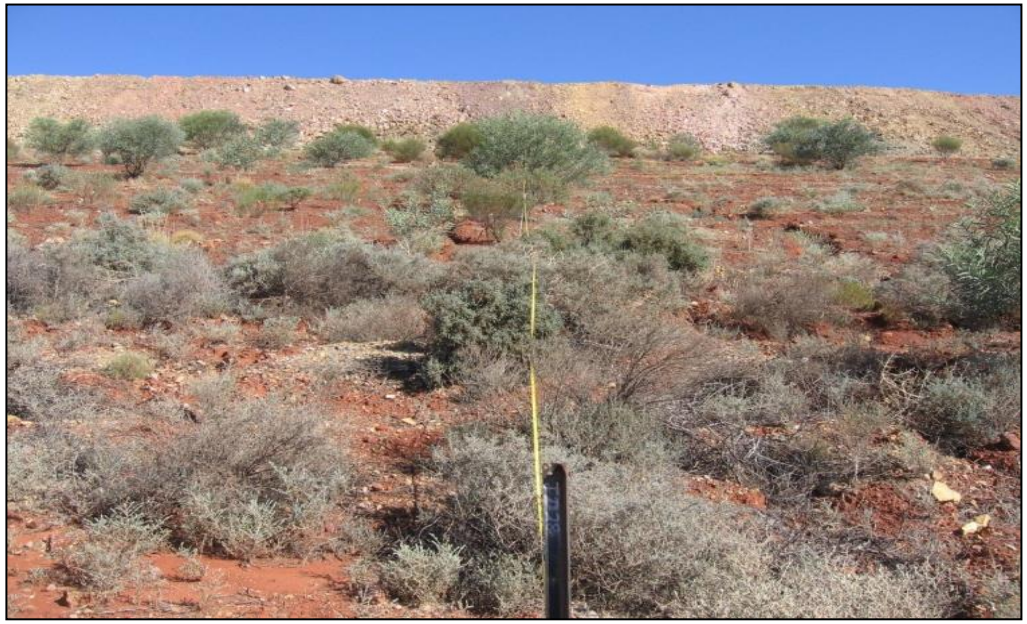
Combined with

Vegetation Assessment
- Plant cover index
- Density (stems/ha)
- Species richness
- Over storey contribution
- Under story contribution
- Weed assessment

EFA

Erosion (rill) Assessment
- Frequency and severity of erosion features
- Cross-sectional area of rills and gullies

Habitat Assessment
- Presence or absence of key indicators
- Visual assessment of utilisation by fauna

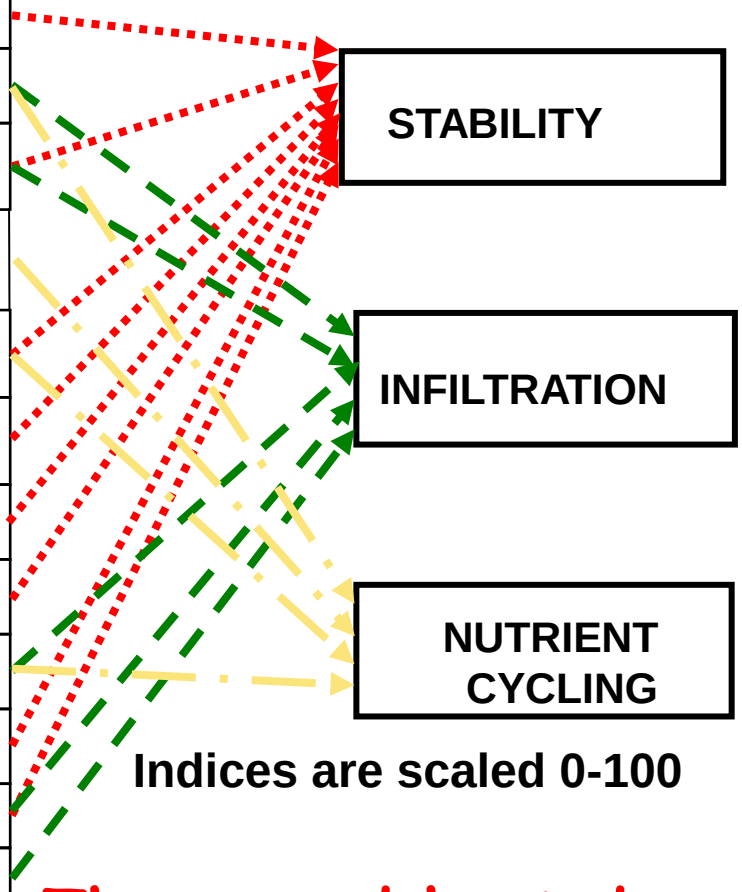


SOIL SURFACE CONDITION INDICIES

Emergent soil surface condition indices

Each indicator is assigned a class value.

Indicator
1. Soil Cover
2. Basal cover of perennial grass
3a. Litter cover
3b. Litter cover, origin and degree of decomposition
4. Soil biological crust cover
5. Crust broken-ness
6. Erosion type & Severity
7. Deposited materials
8. Microtopography
9. Surface resistance to disturb.
10. Slake test
11. Soil texture



Indices are scaled 0-100

The spreadsheet does all these calculations

Time zero

Stability = 40.0

Infiltration = 37.2

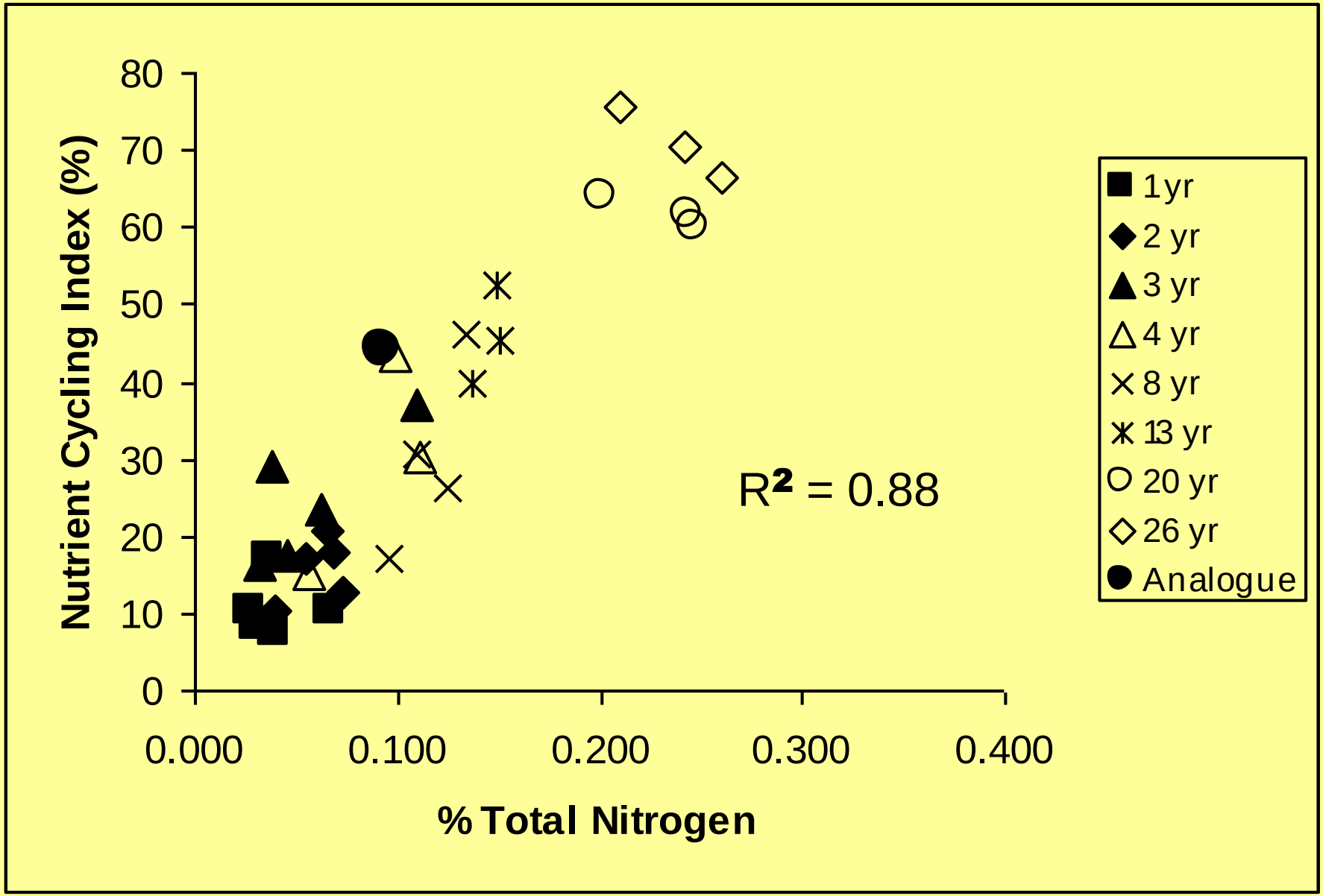
Nutr.Cycl. = 7.8

20 years rehab.

Stability = 82.0

Infiltration = 69.1

Nutr.Cycl. = 68.2

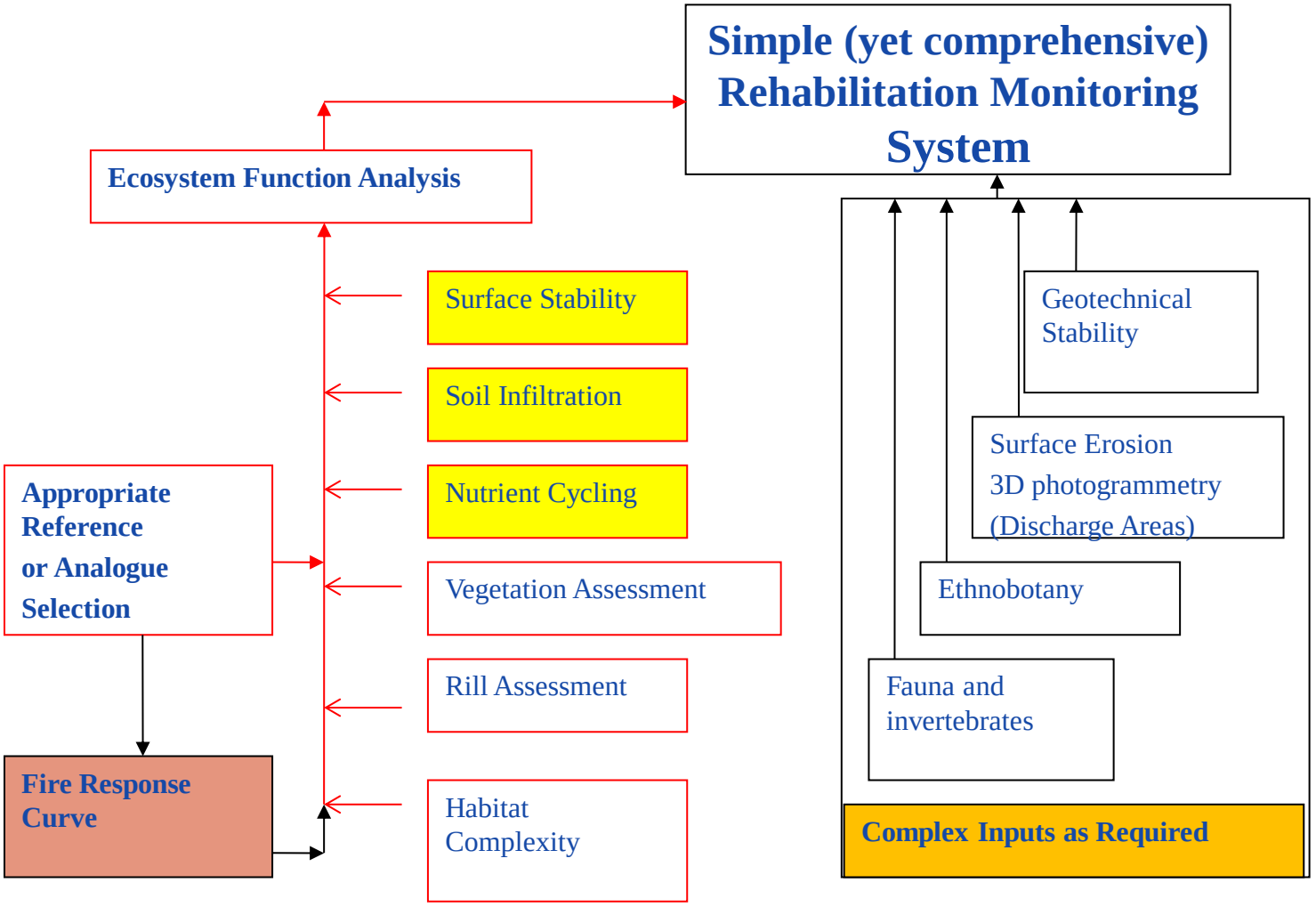


The nutrient cycling index verified by soil Nitrogen conc. increase over time.

We are moving along – but sideways

- Moving towards steadily – function and how to assess
- Occasionally deviate into third part – or remote sensing applications – legal issues, operator bias, regulators uncertain
- Verification is always challenged at some point.
- We are perhaps best choosing the best tools for the system in which the disturbance sits.

Example of a Specific Design Monitoring Suite – Toolbox – in use.

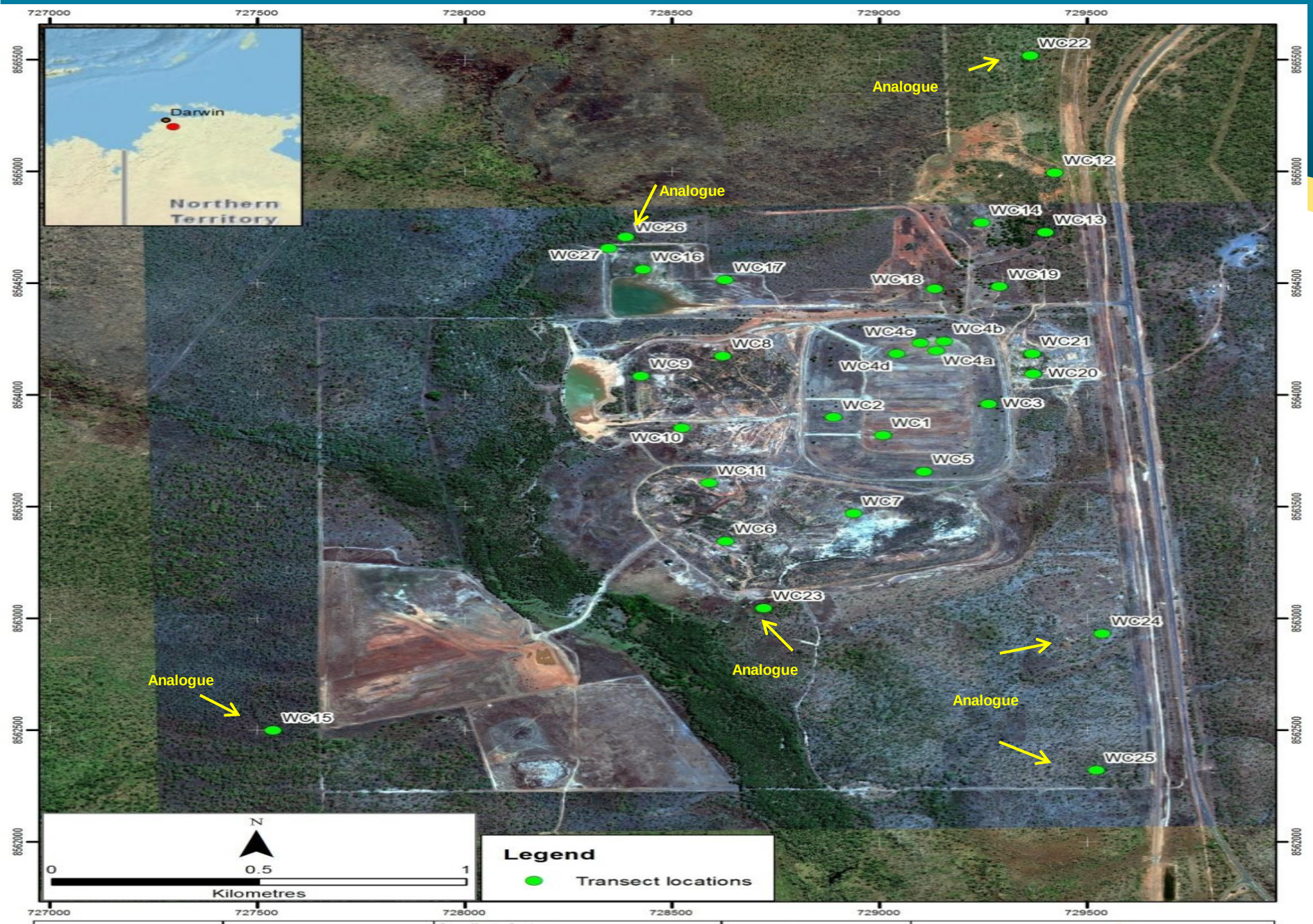


The Role of EFA

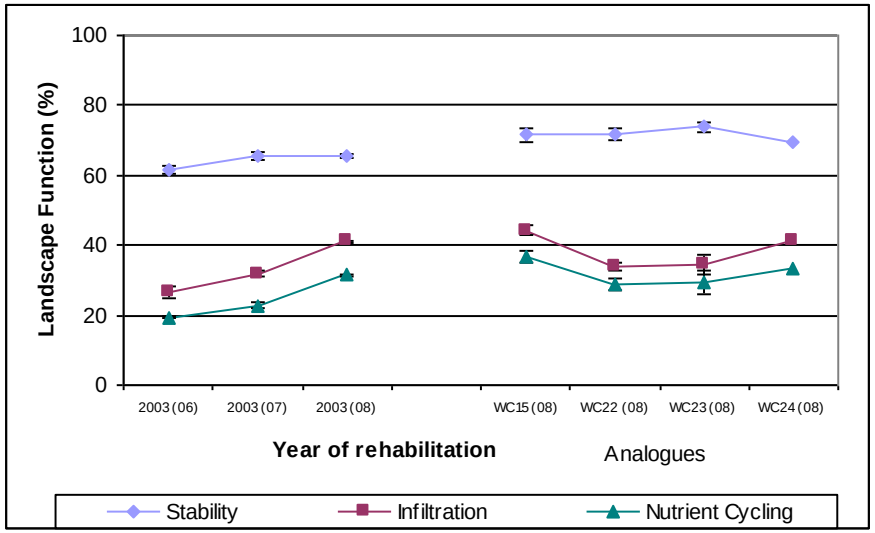
Simple rules for the successful use of EFA:

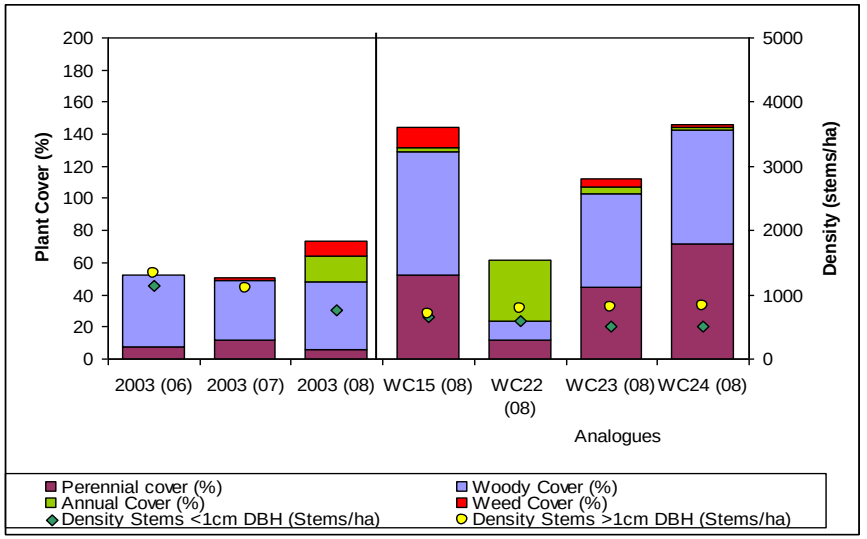
- Users must be trained in the technique and be able to demonstrate their competence
- Field EFA monitoring teams must be lead by experienced practitioners
- Sampling at similar times of year and seasonal conditions (if possible)
- Sampling from the beginning of rehabilitation

Transect Locations



The Role of EFA





2003 Rehabilitation

Former Mill Area

LFA – Progression

2006

2007

2003 Rehabilitation

Former Mill Area

2008

Rehabilitation Development over 7 years

WC06 (TSF 2)

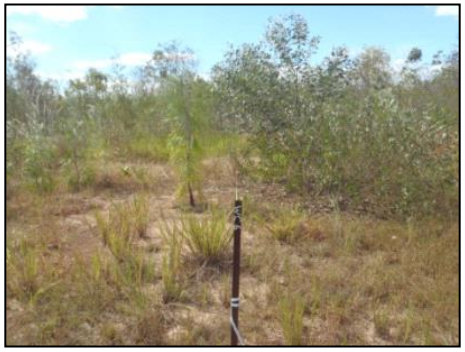
2006

2007

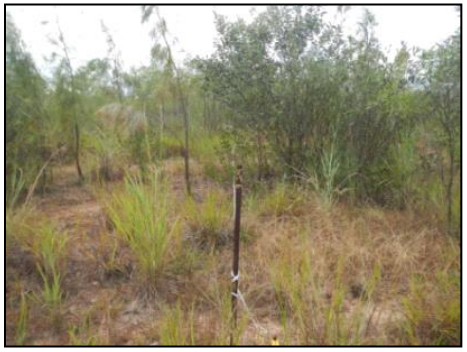
2008

2009

2010

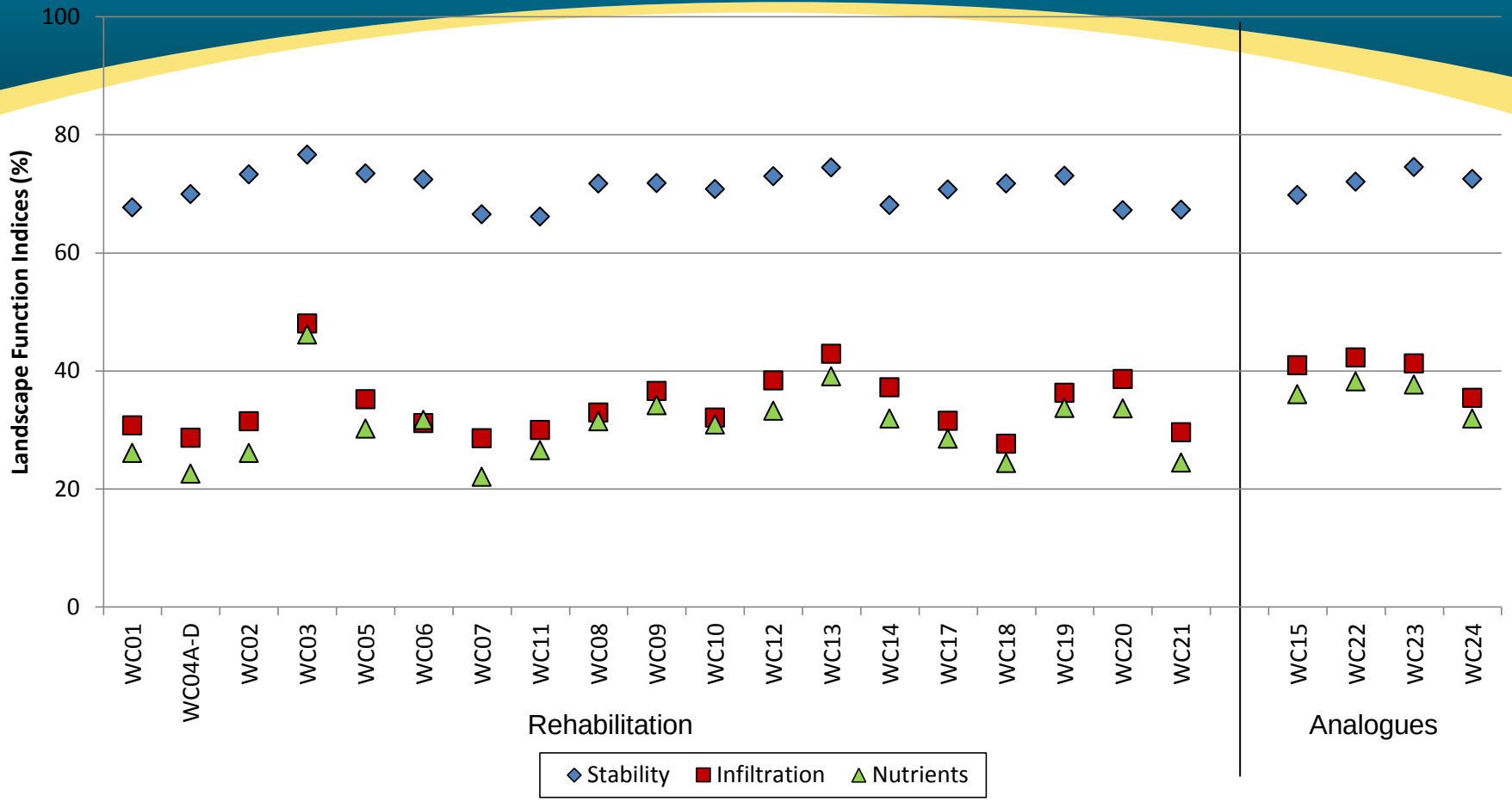


2011



2012

LFA Indices (2012)



Rehabilitation Development over 7 years

WC09 (TSF 1)

2006

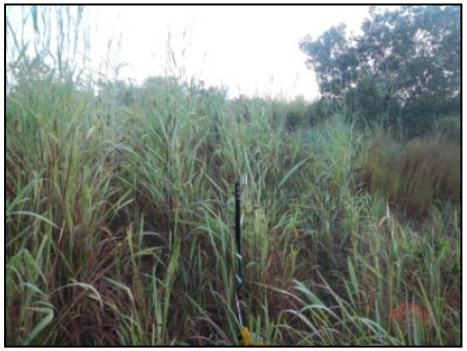
2007

2008

2009

2010

2011



2012

Conclusion

- We have used many tools to monitor function
- We gain the most surety of function so far with LFA – in lockstep with Vegetation Assessment
- “horses for courses” across different landscapes
- We look forward to adapting UAV – Lidar- and other Remote Sensing tools into the toolbox – **we have to**
- Ecologists – Soils Scientists Botanists Forrester- all part of the assessment process
    - Thank You – ASMR