



# **Assessing the success of ecosystem rehabilitation on open cut coal mining in the Bowen Basin, Queensland Australia**

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# Structure of Presentation

- Introduction
- Aim and Objectives of the Study
- Approach
- Rehab Monitoring Data Analyses
- Ecosystem Evolution Modelling
- Way Forward

# Introduction

- **Background**

- EPA figures - increasing gap (since 1990) between disturbance and rehabilitation
- 16% of 70164 ha disturbed, is being rehabilitated.
- Lack of consistent and scientifically acceptable restoration success measures
- Uncertainty of sign-off
- FA bonds - \$12,000.00/ ha.
- = >\$30 million for larger operations

## Introduction

- **Key Questions**

- What encompasses a successful rehabilitation?
- The Regulator is asking;

*“How resilient is the newly rehabilitated area to future disturbance events such as fire, flood or climate change?”* and

*“At what stage of the rehabilitation process can mine closure proceed?”*

- **What is a good measure of ecosystem rehabilitation success?**

## Introduction

Funded by the <sup>then</sup> Australian Centre for Minerals Extension and Research (ACMER) from a Queensland Government Grant through the Centre for Environmental Management, Faculty of Science, Engineering and Health, CQ University Australia.

Acknowledge the assistance and support from Xstrata Coal, Queensland – Newlands Coal Project (Steve Thorne and Trevor Spedding)

# Aims and Objectives

- **Aim**

*develop a meaningful, practical and rigorous system of assessing the success of ecosystem rehabilitation on opencut coal mines in the Bowen Basin*

## Aims and Objectives

# Objectives

1. Critically Review ecosystem restoration theory, practice and monitoring metrics
2. Assess current open cut mine site rehabilitation actions
3. Review ecosystem rehabilitation goals, monitoring methods and indicators
4. Develop a comprehensive integrated and adaptable ecosystem rehabilitation success evaluation system
5. Test the systems against the SMART principles

## Aims and Objectives

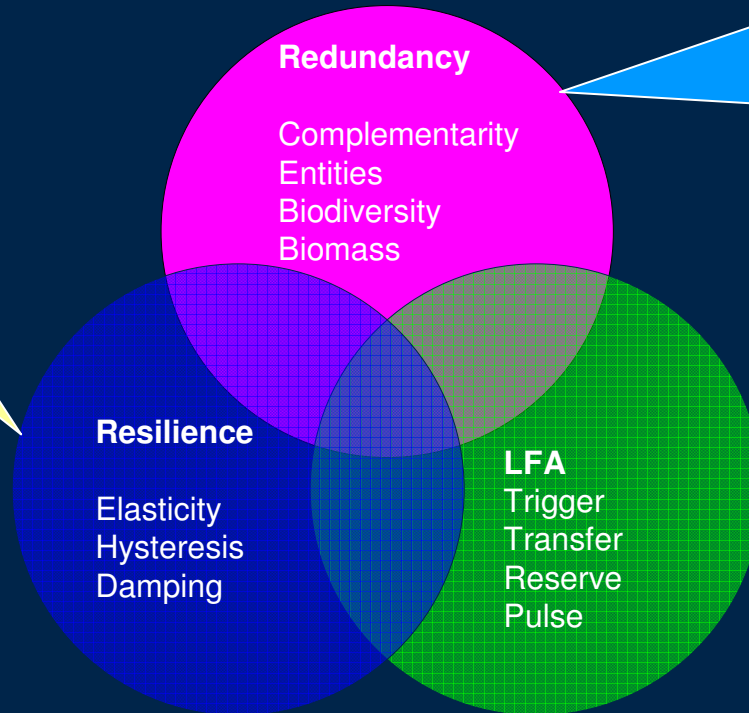
- **S**imple
  - **M**easurable
  - **A**chievable
  - **R**ealistic
  - **T**ime-bound
- 
- Simple rapid scientifically rigorous system

**Success » Industry and regulator acceptance of any proposed system**

# Approach

## Composition & Structure

**Attributes**  
Seed Banks,  
  
Impacts of fire,  
drought and deluge  
  
Time to recovery



**Attributes**  
Ants, Grasshoppers,  
Dung Beetles,  
Arthropods, Mammals,  
Birds,  
  
Plant Structure and  
Cover,  
  
Habitat Heterogeneity

**Attributes**  
Ecological Processes,  
Nutrient Cycling, Soil,  
Organic Matter,  
Infiltration/Runoff  
Landscape Organization

**Dynamics**  
(Temporal changes to  
structure and function)

## Function

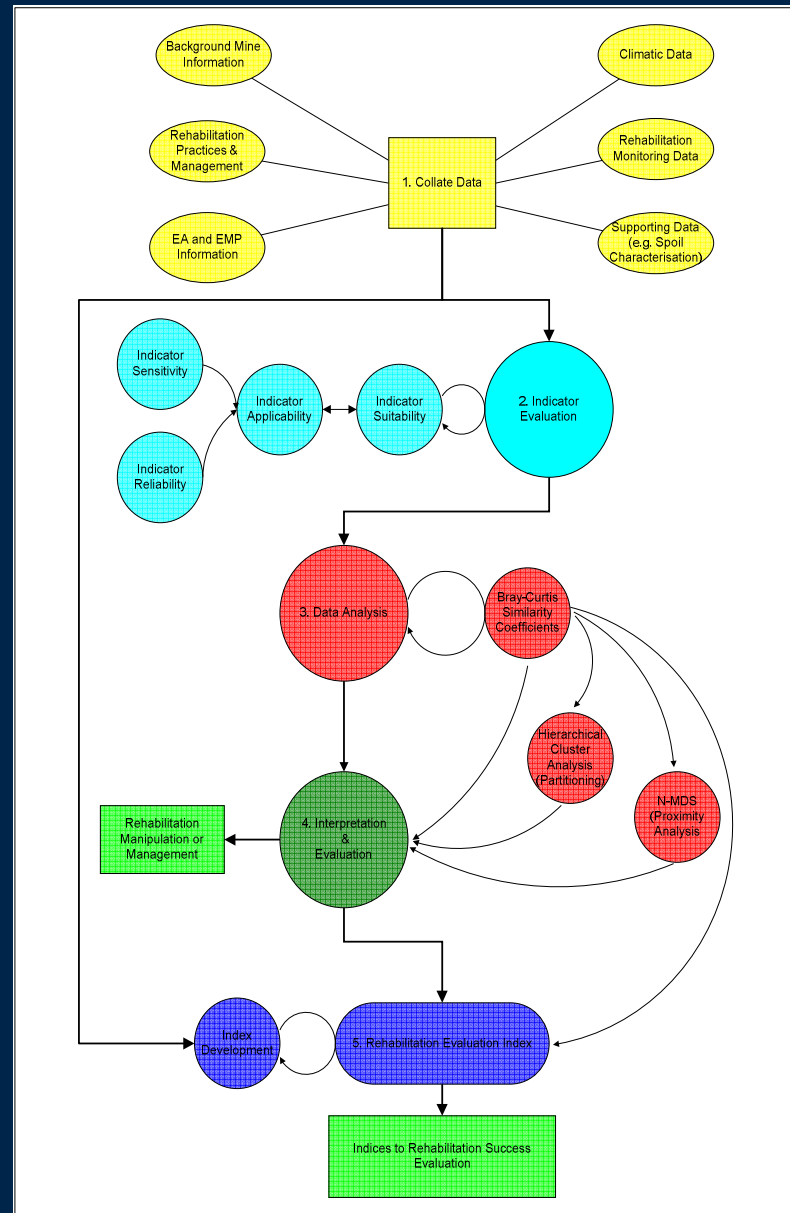
$(C\&S \cap Function \cap Dynamics) = ? \Rightarrow$  Ecological Restoration Performance

## Approach

- The key elements required for any rehabilitation are:
  - landscape reconstruction or landform design,
  - viable root zone establishment, and
  - establishment and maintenance of vegetation cover

(after Bell, 1996).

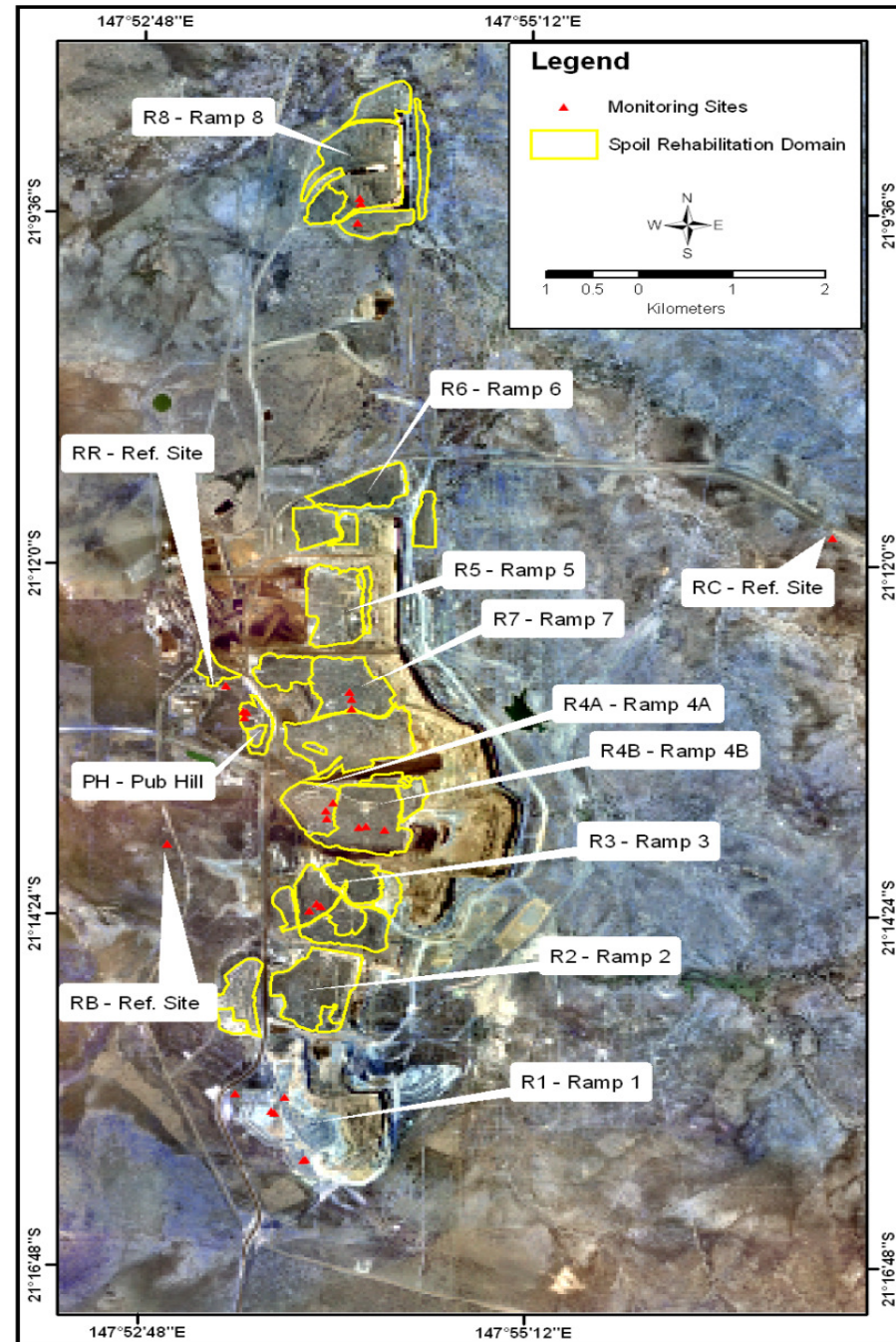
# Rehabilitation Monitoring Data Analyses



# Rehabilitation Monitoring Data Analyses

## Data Collation

Domain Code	Year Established	Description
RC	Reference	Coolibah Grassland
RB	Reference	Brigalow Woodland
RR	Reference	Rosewood Woodland
PH	1992	Pub Hill - out of pit spoil
R4A	1994	Ramp 4 – Dragline Spoil
R3	1996	Ramp 3 – Dragline Spoil
R4B	1999	Ramp 4 – Dragline Spoil
R7	1999	Ramp 7 – Dragline Spoil
R8	1999	Ramp8 – Dragline Spoil
R1Y	2005	Ramp 1 – Spoil Type (Y)ellow
R1G	2005	Ramp1 – Spoil Type (G)rey
R1M	1997	Ramp 1 -(M)ature Slope Test
R1	2005	Ramp 1 Dragline Spoil



## Rehabilitation Monitoring Data Analyses - Indicator Evaluation

Ecosystem Component	Indicator	Criteria	EPA Goal				
			Safe	Non	Stable	Land Use	
Composition & Structure	Vegetation Density (PCQ)	Tree Density		✓	✓	✓	
	Habitat Complexity(EFA)	Habitat Complexity Index		✓	✓	✓	
Ecosystem Function (EFA)	Stability	Rain Splash Protection		✓	✓		
		Cryptogram Cover		✓	✓		
		Crust Brokenness		✓	✓		
		Erosion (Type & Severity)	✓	✓	✓		
		Deposited Materials		✓	✓		
		Surface (Micro-topography)		✓	✓		
		Slakeness		✓	✓		
		Litter Cover		✓	✓	✓	
	Infiltration/Runoff Index	Perennial Vegetation Cover			✓	✓	✓
		Texture					
		Litter (Origin & Decomposition)			✓	✓	✓
		Slakeness			✓	✓	
		Soil Surface Roughness	✓		✓	✓	
		Surface Nature (Reallocated)	✓		✓	✓	
Nutrient Cycling Index	Perennial Vegetation Cover			✓	✓	✓	
	Litter (Origin & Decomp.)			✓	✓	✓	
	Cryptogram Cover			✓	✓	✓	
	Soil Surface Roughness	✓		✓	✓		
Dynamics	No applicable data available						

# Rehabilitation Monitoring Data Analyses

## Data Analyses

### Bray- Curtis Similarity measure

### Hierarchical Cluster Analyses

### Non-Metric Multi Dimensional Scaling (n-MDS)

Habitat Complexity = (EFA HC value/15) \* 100%

% GD = ((Grass Density/Total Plant Density) \* 100 %)

GD = Grass + Shrub Densities

% TD = (Tree Density/Total Plant Density \* 100%)

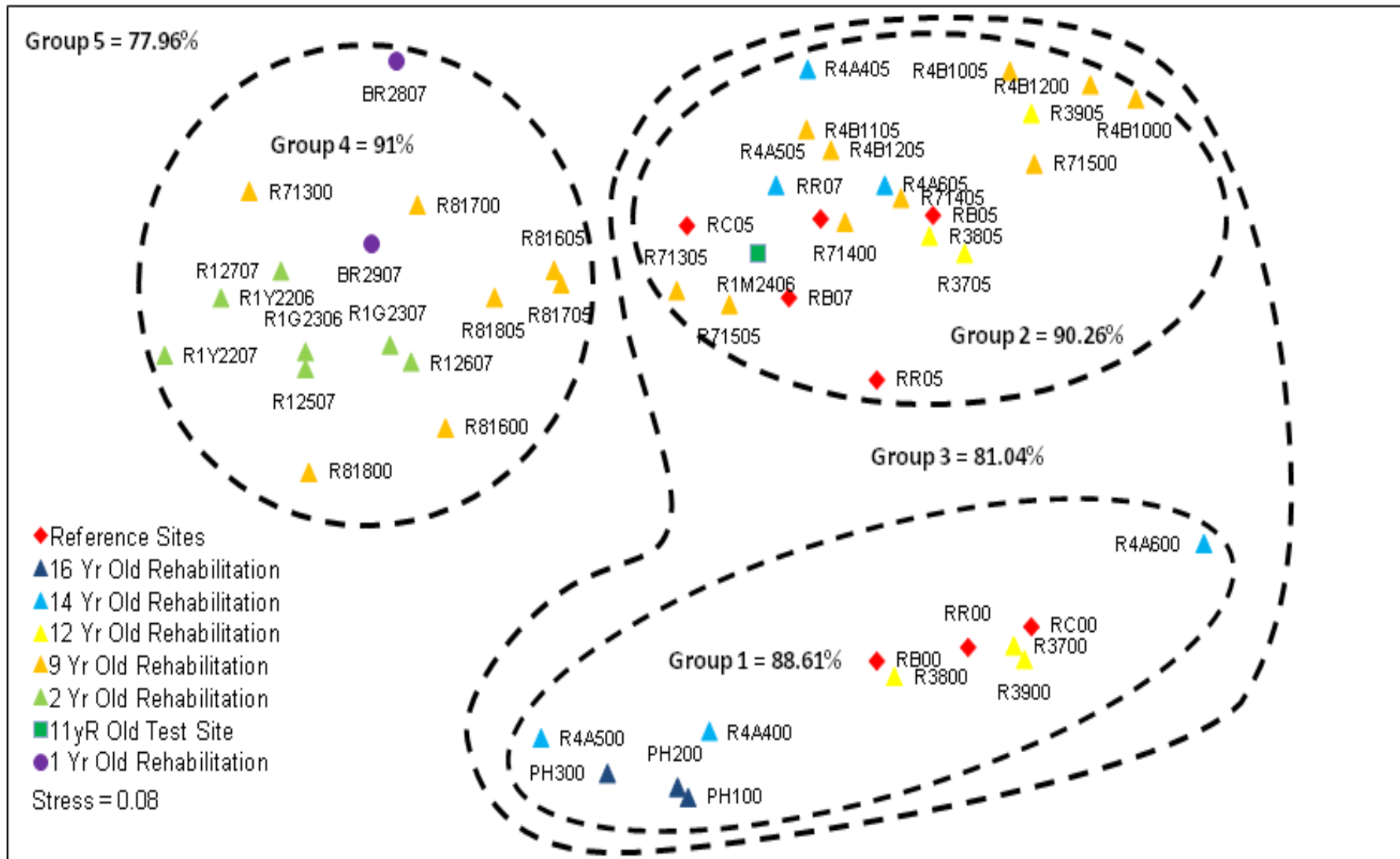
**R41105** Excluded Data (not analysed)

	Stability	Infiltration	Nutrient Status	Habitat Complexity	%GD	%TD
RR00	72.80	39.30	34.70	0.00	99.53	0.47
RR05	74.00	38.10	35.90	22.20	99.33	0.67
RR07	66.30	39.10	32.90	35.53	96.64	3.36
RC00	73.30	40.70	36.60	0.00	99.95	0.05
RC05	62.90	43.30	23.90	28.87	99.97	0.03
RB00	60.70	39.90	33.40	0.00	99.43	0.57
RB05	70.30	46.20	37.80	31.13	98.94	1.06
RB07	70.00	35.70	32.50	28.87	98.65	1.35
PH100	70.30	27.20	25.00	0.00	97.63	2.37
PH200	70.30	28.90	23.30	0.00	97.63	2.37
PH300	62.20	27.00	24.90	0.00	97.63	2.37
PH105	66.00	45.80	40.40	17.80	0.00	100.00
PH205	66.40	42.40	32.50	22.20	0.00	100.00
PH305	68.40	39.50	35.80	20.00	0.00	100.00
R4a400	68.00	30.50	25.40	0.00	99.68	0.32
R4a500	57.50	30.00	23.50	0.00	99.68	0.32
R4a600	66.00	51.80	46.60	0.00	99.68	0.32
R4a405	63.40	49.10	28.80	40.00	99.87	0.13
R4a505	65.60	43.50	28.10	33.33	99.89	0.11
R4a605	68.90	44.30	34.50	35.53	99.84	0.16
R3700	63.70	43.60	37.80	0.00	97.13	2.87
R3800	62.20	40.70	32.50	0.00	97.13	2.87
R3900	67.80	40.30	40.50	0.00	97.13	2.87
R3705	73.20	48.60	36.90	26.67	98.81	1.19
R3805	70.00	47.80	36.30	28.87	98.09	1.91
R3905	67.80	54.30	40.50	33.33	96.17	3.83
R4b1000	69.70	55.90	54.20	29.33	99.66	0.34
R4b1100	67.90	55.20	51.90	31.67	99.66	0.34
R4b1200	63.80	53.80	46.60	33.33	99.66	0.34
R4b1005	64.00	48.50	28.40	35.00	99.70	0.30
R4b1105	63.90	46.30	27.80	33.33		
R4b1205	65.90	48.20	29.50	33.33	100.00	0.00



# Rehabilitation Monitoring Data Analyses

## N-MDS Ordination



## Rehabilitation Monitoring Data Analyses

# Ecosystem Rehabilitation Evaluation Index

Developed based on EA conditions

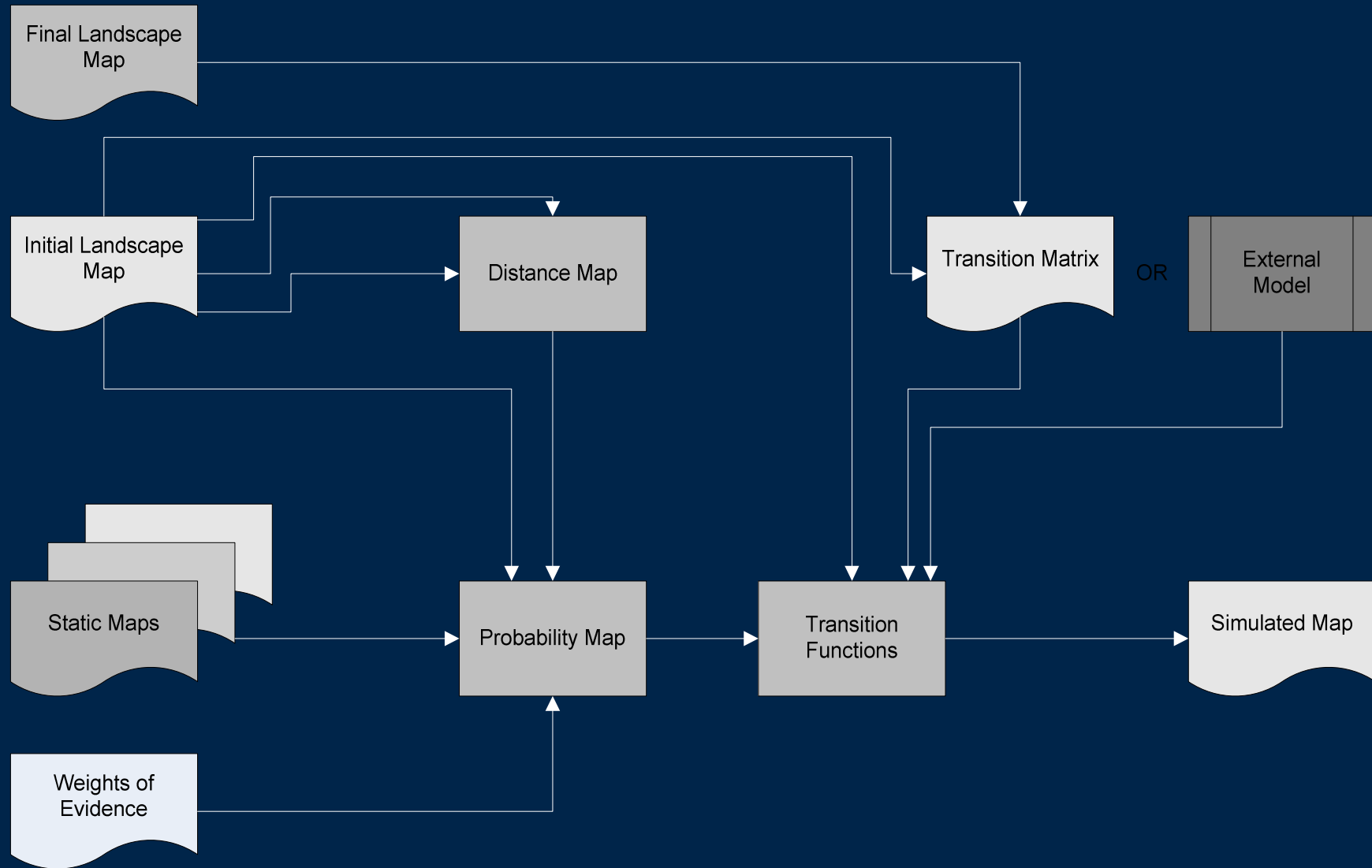
Consultation with and acceptance by the regulator

Domain and Monitoring Yr.	Linkage Value	Score
PH05	44.15%	0
R4A05	96.98%	3
R305	91.42%	3
R4B054	96.98%	3
R705	93.22%	3
R805	77.96%	3
R1Y07	77.96%	3
R1G07	77.96%	3
R1M06	77.96%	3
R107	77.96	3

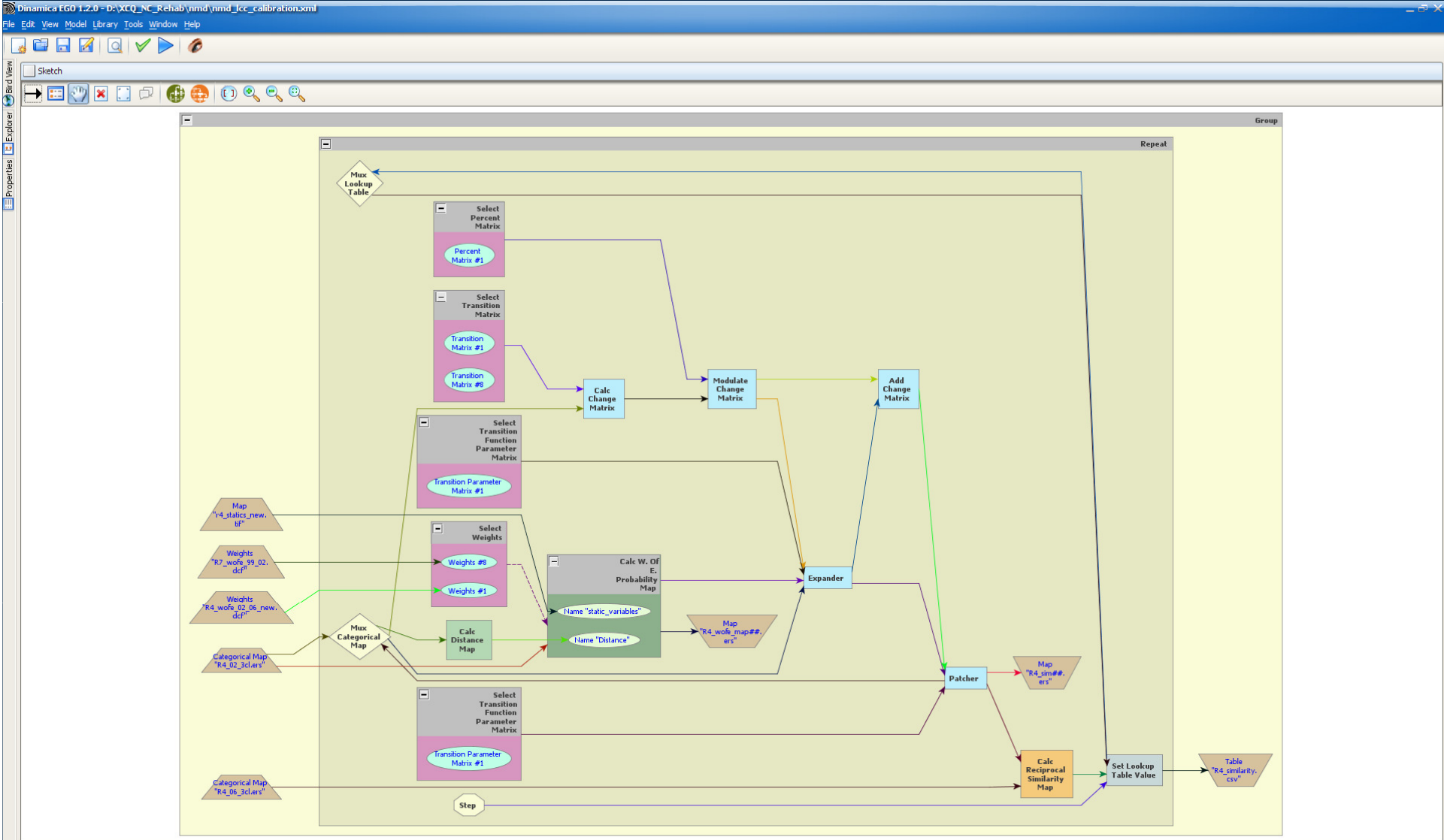
Functional Similarity (%)	Score
<50%	0
50% - < 59.9%	1
60% - 69.9%	2
≥ 70%	3

Feeds into the overall success evaluation measure as parameter 1 of 2

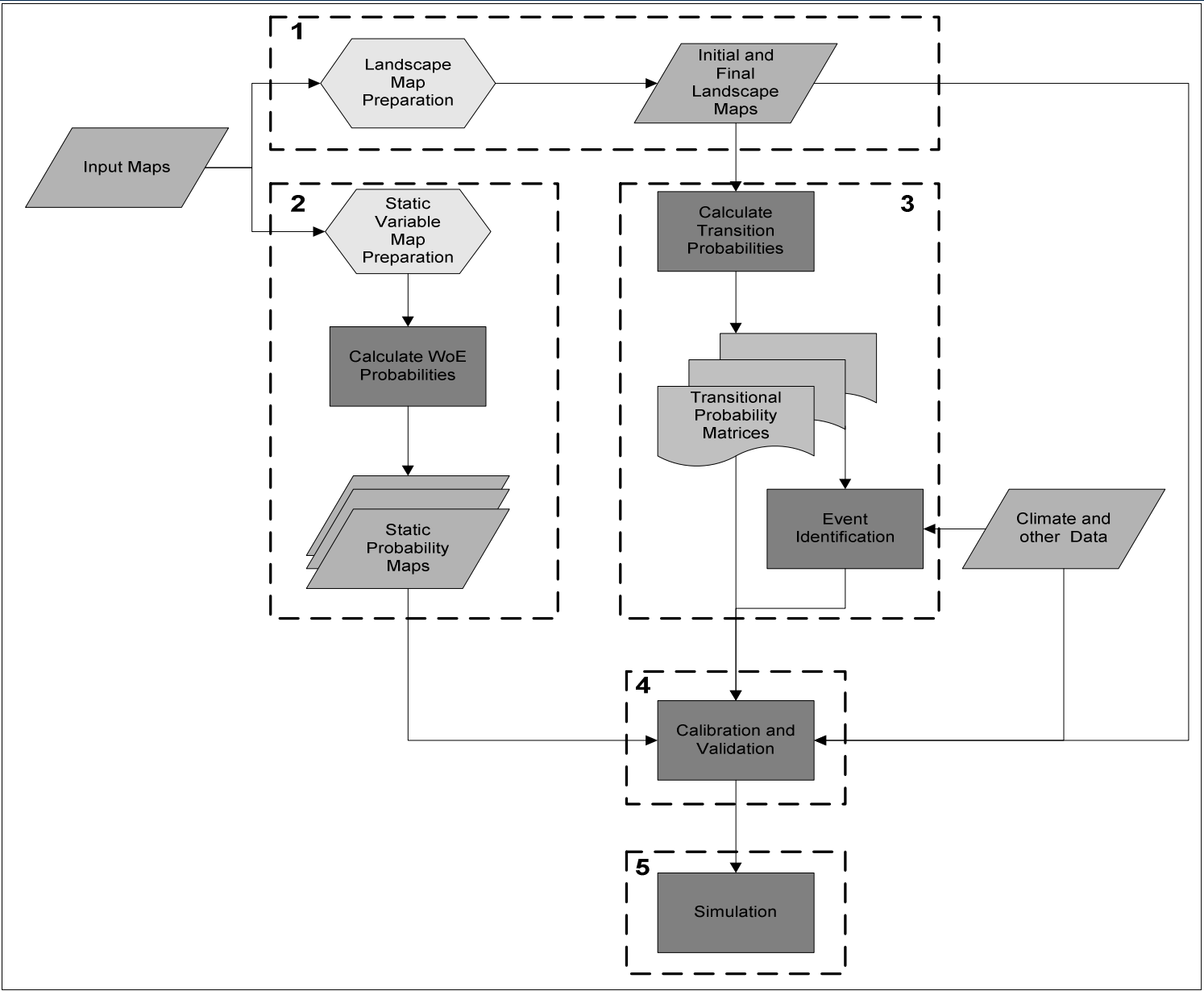
# Rehabilitation Ecosystem Evolution Model



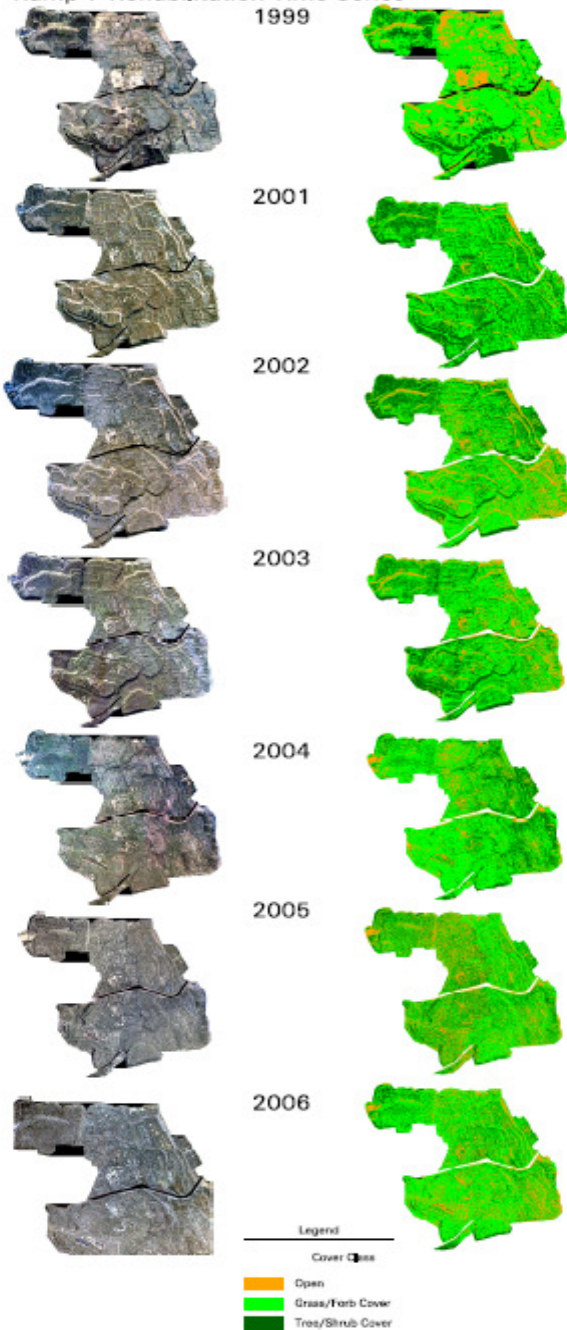
# Rehabilitation Ecosystem Evolution Model



# Rehabilitation Ecosystem Evolution Model






Ramp 7 Rehabilitation Time Series





**Legend**

**Initial 2002**

-  Open
-  Grass/Forb Cover
-  Tree/Shrub Canopy

2006 Simulations

2006 Actual

Ramp 7

Reciprocal Similarity = 80.41

Ramp 4

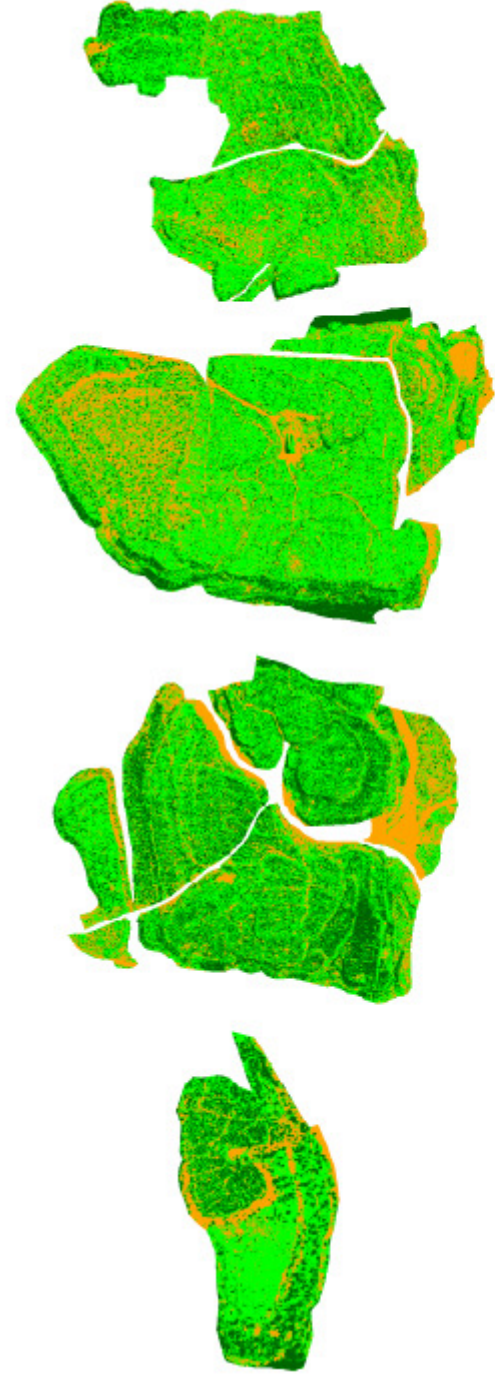
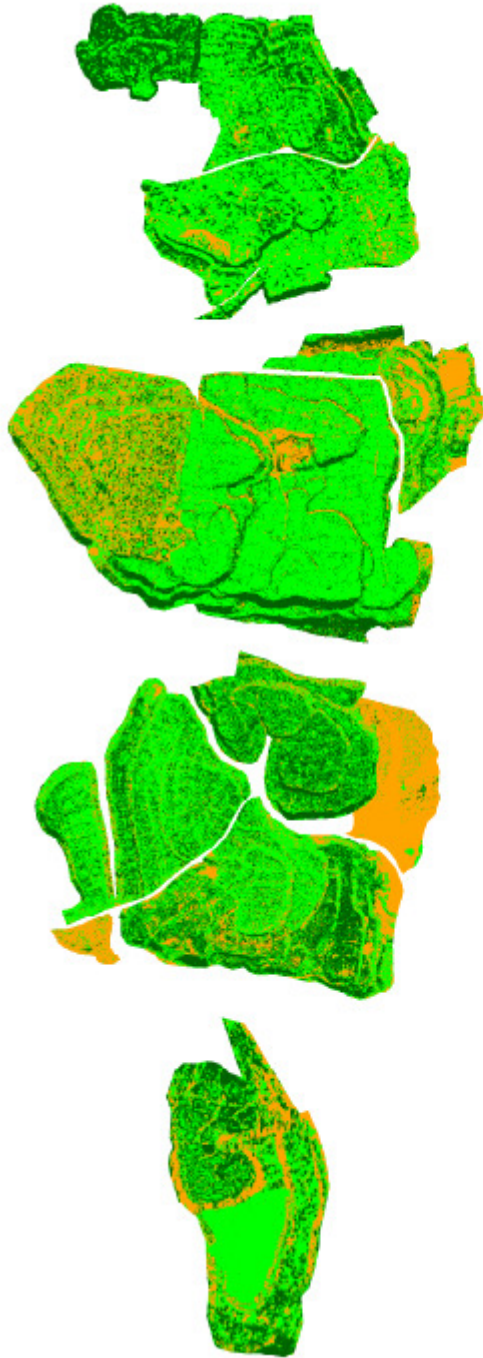
Reciprocal Similarity = 80.75

Ramp 3

Reciprocal Similarity = 82.58

Pub Hill South

Reciprocal Similarity = 84.32



# Way Forward

- Finalise Calibration
  - Test Success Evaluation Risk Assessment method
  - Present Findings to Xstrata Queensland NCP and the EPA
- ## Thank You
- Finalise and submit thesis (May 2009 – hopefully)