

Ecological Monitoring for Successful Restoration

Mark Vergara


Principal Environmental Consultant
Acacia Environmental Management

mark.vergara@acacia.cc

01 October 2020



1



Introduction

Introduction

Ecological Monitoring

Kinds of Monitoring

Effective Monitoring

Importance of Monitoring

Let's Get Technical

Citizen Science

Monitoring & Evaluation


Summary

Q&A


Mark Vergara

- Acacia Environmental Management
- ~20 years experience
- Assoc. Environmental Technology, USA
- BSc Ecology, Philippines;
- MSc Marine Biology, Philippines;
- GC Arboriculture (ongoing, UniMelb)

- wetlands management and water quality monitoring, Florida
- coastal resource assessment and monitoring, SE Asia; Middle East
- urban planning, habitat restoration and habitat creation in Asia; **wn**
- water quality monitoring and ecological assessments in Victoria


2

2



Definitions

Introduction

Ecological Monitoring

Kinds of Monitoring

Effective Monitoring

Importance of Monitoring

Let's Get Technical


Citizen Science

Monitoring & Evaluation


Summary

Q&A

- to watch and check something over a period of time in order to see how it develops, so that you can make any necessary changes – Oxford Dictionary
- Synonyms: Track and Follow
- repeated field-based empirical measurements are collected continuously and then analyzed (Lindenmayer & Likens 2010)
- the process of purposefully collecting information to track and understand changes in ecosystem structure, ecological processes, and the ecological services that ecosystems provide (Lindenmayer & Likens 2018)


3

3



Long-term Monitoring

Introduction

Ecological Monitoring

Kinds of Monitoring

Effective Monitoring

Importance of Monitoring

Let's Get Technical

Citizen Science

Monitoring & Evaluation

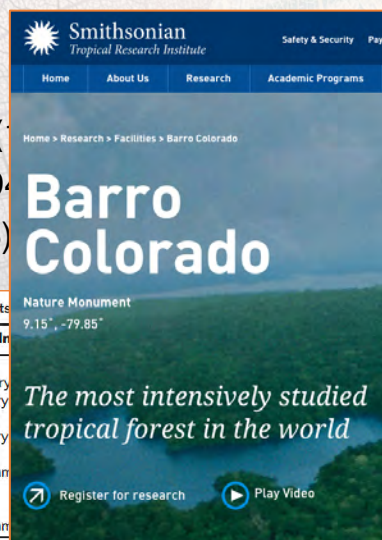
Summary


Q&A

- Barro Colorado, Panama (1923)
- Koonamore Vegetation Reserve, SA (1941)
- Alpine Long Term Monitoring, VIC (1946)
- AIMS LTMP Great Barrier Reef (1983)


Table 1. Examples of some long-term ecological studies and the institutional arrangements

| Initiated | Management purpose | Institution |
|-----------|--|------------------|
| 1925 | To study recovery after grazing in rangelands | University |
| 1941 | To investigate insect damage in multispecies tree plantings | State Forestry |
| 1946 | To investigate the ecological consequences of different fire regimes in a subtropical dry sclerophyll forest | State forestry |
| 1957 | To investigate tree regeneration following different forms of logging in subtropical forests | State forestry |
| 1963 | To study successional recovery following clearing of <i>Acacia harpophylla</i> (brigalow) forest | State government |
| 1963 | To observe seedling recruitment in tropical rainforest | University |
| 1967 | To investigate the population dynamics of plants in rangelands | State government |




4

4



YARRA RIVERKEEPER

Long-term Monitoring

Introduction

Ecological Monitoring

Kinds of Monitoring

Effective Monitoring

Importance of Monitoring


Let's Get Technical

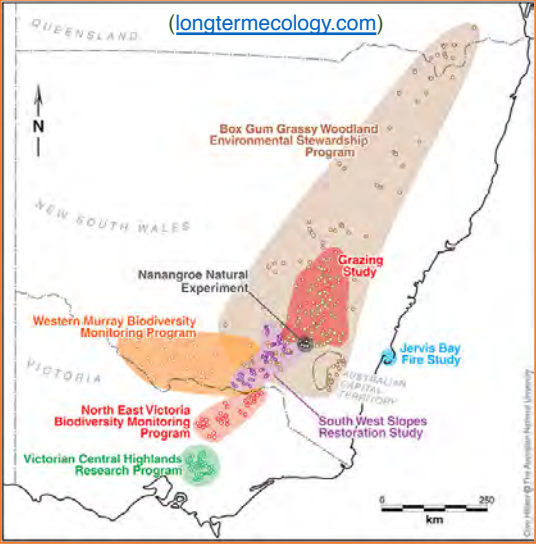
Citizen Science

Monitoring & Evaluation


Summary

Q&A





5



YARRA RIVERKEEPER

Kinds of Monitoring

Introduction

Ecological Monitoring

Kinds of Monitoring

Effective Monitoring

Importance of Monitoring

Let's Get Technical

Citizen Science

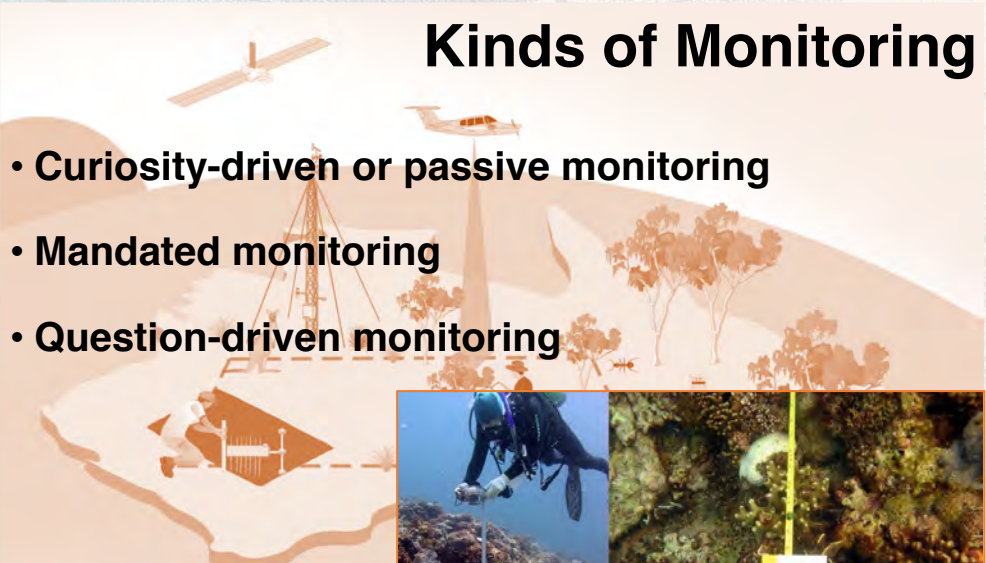

Monitoring & Evaluation

Summary


Q&A

- **Curiosity-driven or passive monitoring**
- **Mandated monitoring**
- **Question-driven monitoring**

(Lindenmayer & Likens 2010)

6



Question-driven Monitoring

Introduction

Ecological Monitoring

Kinds of Monitoring

Effective Monitoring

Importance of Monitoring

Let's Get Technical


Citizen Science

Monitoring & Evaluation

Summary


Q&A

| Type of monitoring | Goal-oriented question | Design approach |
|--------------------|--|--|
| Surveillance | Are ecological properties changing in some undesirable way through time, or do we perceive an association between a particular land-use activity and a negative indicator? | Re-sampling ecological response variables through time; establishing time series data; looking for correlations between land-use and the presence or absence of some indicator |
| Implementation | Was management prescription implemented according to contract specifications? | Project-specific qualitative and quantitative data collection (not necessarily requiring statistical design) |
| Effectiveness | Did management actions achieve the social, economic, or ecological goals and objectives outlined in the prescription? | BACI design of treatments (ANOVA); chronosequence study of past treatments (correlation or hierarchical statistical modeling) |
| Ecological effects | Did management actions result in ecological tradeoffs or unintended ecological consequences? | BACI design of treatments (ANOVA); chronosequence study of past treatments (correlation or hierarchical statistical modeling) |



(Hutto and Belote 2013)

7



Characteristics of Effective Monitoring

Introduction

Ecological Monitoring

Kinds of Monitoring

Effective Monitoring

Importance of Monitoring


Let's Get Technical

Citizen Science

Monitoring & Evaluation


Summary

Q&A




Characteristic 1

Fit for purpose




Characteristic 2

Early use of data to examine its properties and test assumptions



Characteristic 3


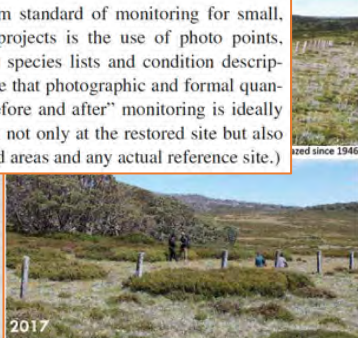
High level of data curation and management




Characteristic 4

Communication of lessons learned and outcomes generated


A minimum standard of monitoring for small, volunteer projects is the use of photo points, along with species lists and condition descriptions. (Note that photographic and formal quantitative "before and after" monitoring is ideally undertaken not only at the restored site but also at untreated areas and any actual reference site.)



(Burns et al. 2018; LTERN 2014)

8



YARRA RIVERKEEPER

Fit for Purpose

Introduction

Ecological Monitoring

Kinds of Monitoring

Effective Monitoring

Importance of Monitoring




Let's Get Technical

Citizen Science

Monitoring & Evaluation







Summary

Q&A

Characteristic 1—Fit for purpose

Based on its purpose and objectives, the monitoring design has chosen:

-  sound statistical principles
-  an accurate and useful conceptual model
-  relevant and answerable questions
-  relevant and measurable entities to monitor
-  sound data collection methods
-  an appropriate scale of operations.







Figure 1.5 Use of fixed quadrats, placed within representative areas of two communities, fails to detect boundary change (a). Extra quadrat (b) on boundary detects change but use of transect (c) provides more information. (i) Before; (ii) after.

(Goldsmith 1991, Monitoring for Conservation and Ecology; Burns et al. 2018; LTERN 2014)

9



YARRA RIVERKEEPER

Conceptual Models

Introduction

Ecological Monitoring

Kinds of Monitoring

Effective Monitoring

Importance of Monitoring

Let's Get Technical

Citizen Science

Monitoring & Evaluation

Summary

Q&A

Multiple stressors affecting coral

Global Change and Increased Temperature

SEDIMENT STRESS

TURBIDITY

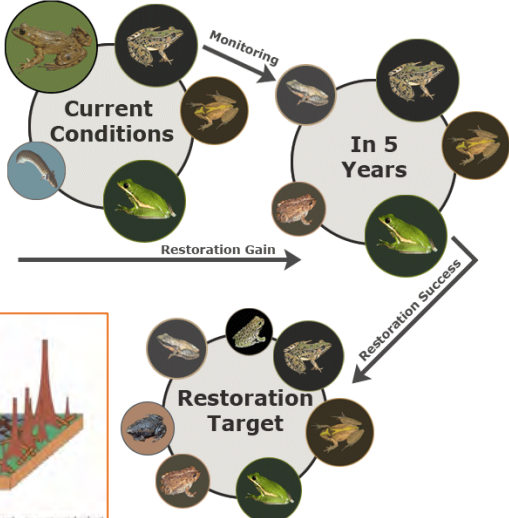
Contaminated surface waters

NUTRIENTS

Contaminated

Excess algal overgrowth coral

Dryland Grazing Management



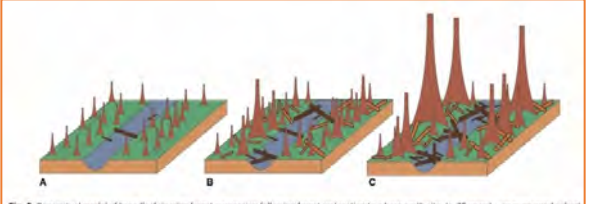


Fig. 5. Conceptual model of broadleaf riparian forest succession following forest restoration to a bare earth site. (a, 25 years) – an even-aged cohort.


(Szmant 2002)

(Lewis 2020)

(Dixon et al. 2018)

(Rice et al. 2006)


10



Importance of Monitoring


- identify whether the actions are working as expected or need to be modified
- provide evidence to stakeholders that specific goals are being achieved; and,
- answer specific questions (McDonald et al. 2016; SERA 2017)
- Without monitoring, policy-making and management will be largely devoid of evidence and unable to demonstrate return on environmental investment by funding agencies (Lindenmayer et al. 2018)

Introduction
Ecological Monitoring
Kinds of Monitoring
Effective Monitoring
Importance of Monitoring
Let's Get Technical
Citizen Science
Monitoring & Evaluation
Summary
Q&A



11

11



Case in Point

Project Name: The Regent Honeyeater Habitat Restoration Project

Project Location: Lurg Hills, near Benalla, Victoria, Australia


Project Goals: The broad aim of the Regent Honeyeater Project (RHP) is to protect and restore all significant remnants of Box-Ironbark and Box-Gum Grassy Woodland habitat in the Lurg Hills and to reconnect them through revegetation. Strategic focus is placed on higher fertility sites while also forming links to drier upland habitats.

Time Frame: 1996-05-04 : 2009-05-04

Monitoring: The project does not have a monitoring plan.

Ecological Outcome Achieved: Since its inception in the early 1990s, the project has protected and restored almost 1060 ha of Box-Ironbark habitat, and planted more than 385,000 seedlings...The gap closure achieved within the district **seems to have substantially benefited** the Grey-crowned Babbler...


Introduction
Ecological Monitoring
Kinds of Monitoring
Effective Monitoring
Importance of Monitoring
Let's Get Technical
Citizen Science
Monitoring & Evaluation
Summary
Q&A




(Society for Ecological Restoration 2020)

12


12



- Introduction
- Ecological Monitoring
- Kinds of Monitoring
- Effective Monitoring
- Importance of Monitoring**
- Let's Get Technical
- Citizen Science
- Monitoring & Evaluation
- Summary
- Q&A



Case in Point



HOME ABOUT PROJECT DATABASE STAPER RESOURCE DATABASE SER RESOURCES RESTORATION DIRECTORY


Home » Projects

Australia: Restoration in a global biodiversity hotspot in Western Australia

Monitoring

The project does not have a monitoring plan.

13




- Introduction
- Ecological Monitoring
- Kinds of Monitoring
- Effective Monitoring
- Importance of Monitoring
- Let's Get Technical**
- Citizen Science
- Monitoring & Evaluation
- Summary
- Q&A



Let's Get Technical


- Environmental Monitoring
- BACI
- Ecological Succession
- Edge Effects
- Keystone Species
- Indicator Species
- Stochastic Event

SPECIES – a group of living organisms consisting of similar individuals capable of exchanging genes or interbreeding. Species is both plural and singular



SPECIE – money in the form of a coin

14



**YARRA
RIVERKEEPER**

Told you it will work ...

Introduction

Ecological Monitoring

Kinds of Monitoring

Effective Monitoring

Importance of Monitoring

Let's Get Technical

Citizen Science

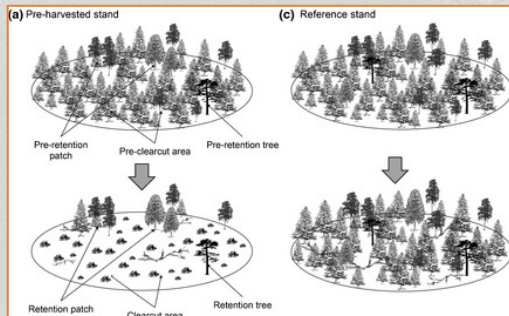
Monitoring & Evaluation

Summary

Q&A

Environmental Monitoring - refers to measurement of abiotic parameters to characterise the quality of the environment (air, water, soil, temperature, rainfall) and typically associated with impact assessments.

BACI - Before-After-Impact-Control design or sampling




(a) Pre-harvested stand

(b) Harvested stand (clearcut with retention)

(c) Reference stand

| | BEFORE | AFTER | |
|------------------------|--------|-------|---------|
| Road-Construction BACI | | | IMPACT |
| | | | CONTROL |
| Road-Modification BACI | | | IMPACT |
| | | | CONTROL |
| Road-Removal BACI | | | IMPACT |
| | | | CONTROL |

15



**YARRA
RIVERKEEPER**

There is nothing permanent except change...

Introduction

Ecological Monitoring

Kinds of Monitoring

Effective Monitoring

Importance of Monitoring

Let's Get Technical

Citizen Science


Monitoring & Evaluation

Acknowledgements

Q&A

Ecological succession

- the series of stages by which a group of organisms living in a community reaches its final stable state or climax (primary succession)
- where colonizer plant species grow quickly to provide organic matter, shelter and nutrients to their longer-lived neighbours (primary succession) – Landscape Australia
- can be defined as any landscape's evolution from disturbance (secondary succession) – Landscape Australia




SEA BEACH Grasses Pioneer shrubs e.g. Coast Wattle Tea-tree scrub Banksia, She-oak Eucalypts with healthy understorey SAND

(Costermans 2006)

16

8



YARRA
RIVERKEEPER

Ecological Succession

Introduction

Ecological Monitoring

Kinds of Monitoring

Effective Monitoring

Importance of Monitoring


Let's Get Technical

Citizen Science

Monitoring & Evaluation

Summary

Q&A




A recently burned patch at Bay Road Heathland Sanctuary colonised by Chocolate Lilies and Sandhill Sword Sedges.
Image: Lyndsey Vivian

| Species | Site number | | | | | | | | | | |
|------------------------------------|-------------|----|----|----|----|----|-----|----|----|----|----|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | |
| <i>Eucalyptus camaldulensis</i> | †† | 73 | 27 | 88 | 80 | 88 | 96 | 86 | 71 | 94 | 84 |
| <i>E. grandis</i> | – | – | – | – | – | – | – | – | – | 70 | 72 |
| <i>E. melliodora</i> | †† | 93 | 21 | 0 | 11 | 58 | 72 | 80 | 75 | – | – |
| <i>Corymbia maculata</i> | – | 0 | – | – | – | – | – | – | – | – | 47 |
| <i>Angophora floribunda</i> | – | 16 | 11 | 18 | 16 | 8 | 67 | – | 17 | – | – |
| <i>Acacia salicina</i> | †† | 10 | 7 | 3 | 14 | 20 | 33 | 8 | 7 | – | 6 |
| <i>A. fimbriata</i> | – | 0 | 0 | – | – | – | – | – | – | 6 | 0 |
| <i>A. decurrens</i> | – | – | – | – | 0 | 13 | 0 | – | 0 | 0 | 0 |
| <i>A. longifolia</i> | †† | – | – | – | 29 | 0 | 11 | 0 | – | 0 | 0 |
| <i>A. speciosa</i> | – | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | – | – |
| <i>Leptospermum polygalifolium</i> | – | – | – | – | – | – | – | – | – | 10 | 0 |
| <i>Melaleuca styphelioides</i> | †† | 10 | 0 | 0 | 24 | 0 | 83 | – | 0 | 83 | – |
| <i>M. linariifolia</i> | †† | 10 | – | – | – | 0 | 100 | – | 0 | – | 5 |
| <i>Grevillea robusta</i> | – | 80 | – | 40 | 80 | – | 100 | – | – | 88 | – |

(Kirkpatrick 2018)


(Vivian 2018)

(Webb and Erskine 2003)



17

17



YARRA
RIVERKEEPER

The whole is greater than the sum of its parts

Introduction

Ecological Monitoring

Kinds of Monitoring

Effective Monitoring

Importance of Monitoring

Let's Get Technical

Citizen Science

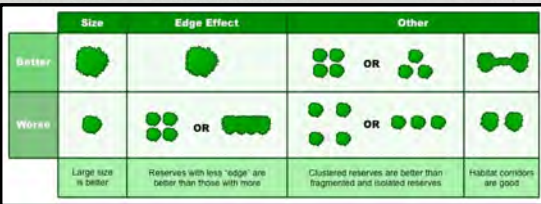
Monitoring & Evaluation

Summary

Q&A

Edge Effects - refer to the changes in population or community structures that occur at the boundary of two habitats or different landscapes

- the effect of an abrupt transition between two quite different adjoining ecological communities on the numbers and kinds of organisms in the marginal habitat – Merriam Webster

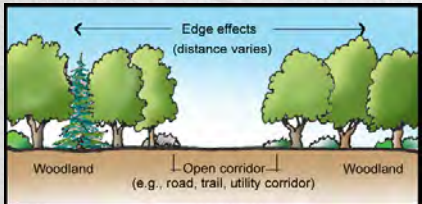


Size: Large size is better

Edge Effect: Reserves with less 'edge' are better than those with more

Other: Clustered reserves are better than fragmented and isolated reserves

Habitat corridors are good




Edge effects (distance varies)

Woodland

Open corridor (e.g., road, trail, utility corridor)

Woodland




Bioninja 2020


USDA 2020

18

18




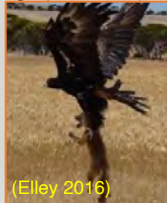
- Introduction
- Ecological Monitoring
- Kinds of Monitoring
- Effective Monitoring
- Importance of Monitoring
- Let's Get Technical**
- Citizen Science
- Monitoring & Evaluation
- Summary
- Q&A



We are not worthy ...

Keystone Species - a species that plays a centrally important role in an ecosystem, often disproportionate to its biomass, and whose removal would alter or endanger the entire ecosystem


Australia's keystone endangered species:
Southern cassowary; Northern quoll; Grey-headed flying-fox; Gilbert's potoroo; Grey nurse shark; Tasmanian devil; Red tailed black cockatoo; Tasmanian wedge-tailed eagle; Great white shark; Australian sea lion (Australian Geographic 2014)

Mark Vergara
Principal Environmental Consultant at Acacia Environmental Management
3d • 🌐


Chain Reaction ...

Over predation of feral foxes and cats on Bilbys lead to uncontrolled population of giant scorpions in the Murray-Darling Basin and Mallee region.
[#wildlifeconservation](#) [#invasivespecies](#)




Why giant scorpion populations are surging in parts of Victoria and NSW
 3aw.com.au • 1 min read

19




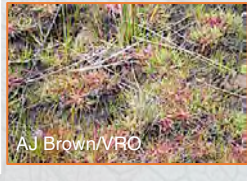
- Introduction
- Ecological Monitoring
- Kinds of Monitoring
- Effective Monitoring
- Importance of Monitoring
- Let's Get Technical**
- Citizen Science
- Monitoring & Evaluation
- Summary
- Q&A




Early Warning Device

Indicator species - a species which is very sensitive to particular changes in the environment and can show that environmental changes are taking place


| Species /Element | Indicator |
|-----------------------------|---------------------------------|
| Buck's Horn Plantain | High Salinity |
| Hydrangea | Soil Acidity (Acidic = Blue) |
| Samphire, Saltbush, Pigface | Saltwater Intrusion |
| Algal Blooms | Elevated Nutrient Levels |
| Blue Corals | Submarine Groundwater Discharge |
| Platypus | Improving Water Quality |
| Estuary Stingray | Good habitat |

20




- Introduction
- Ecological Monitoring
- Kinds of Monitoring
- Effective Monitoring
- Importance of Monitoring
- Let's Get Technical**
- Citizen Science
- Monitoring & Evaluation
- Summary
- Q&A




Act of God

Stochastic Event – unpredictable fluctuations in environmental conditions that affect populations and ecological processes

- an **act of God** colloquially refers to any event that occurs outside of human control and that can't be predicted or prevented




Ian Hitchcock/Getty Images




21

21



- Introduction
- Ecological Monitoring
- Kinds of Monitoring
- Effective Monitoring
- Importance of Monitoring
- Let's Get Technical
- Citizen Science**
- Monitoring & Evaluation
- Summary
- Q&A




Ecology is not rocket science. It's much more complicated than that!

Citizen Science – scientific research carried out by amateurs, typically involving large scale data collection


- research and observation carried out by nonprofessional individuals, teams or networks of volunteers

- iNaturalist
- Yarra Catchment Atlas
- VBA Go
- WOW



22

22



YARRA RIVERKEEPER

Monitoring & Evaluation

Introduction

Ecological Monitoring

Kinds of Monitoring

Effective Monitoring

Importance of Monitoring

Let's Get Technical

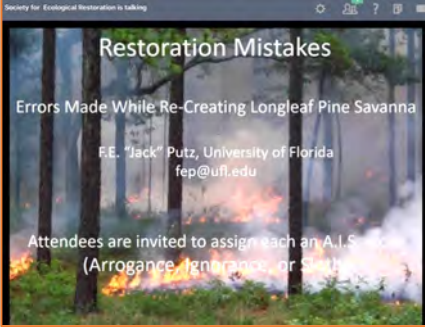
Citizen Science

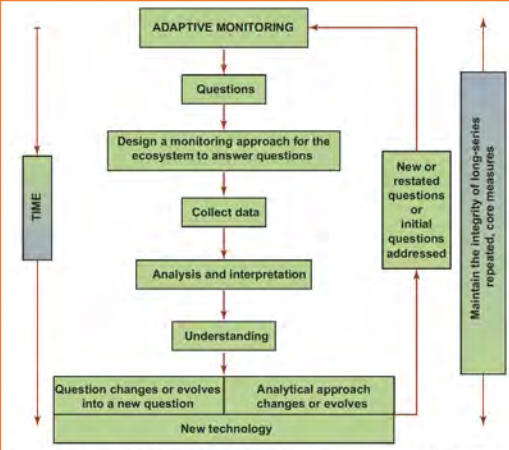
Monitoring & Evaluation

Summary

Q&A

Evaluation - The systematic investigation of whether a program is effective: whether the activities implemented are having the desired effect (WHO)






The adaptive monitoring framework (redrawn from Lindenmayer and Likens 2009)

23

23



YARRA RIVERKEEPER

Technical Review of Kallang River Restoration Project

Introduction

Ecological Monitoring

Kinds of Monitoring

Effective Monitoring

Importance of Monitoring

Let's Get Technical

Citizen Science

Monitoring & Evaluation

Summary


Q&A

- Kallang River – Bishan – Ang Mo Kio Park, Singapore
- Restoration of 2.7km concrete canal
- SGD50 million (river & WSUD)

Technical Review after 2 years

- Hydraulic Modelling
- Bioengineering
- Ecology
- WSUD


Lessons Learnt & Rectification Works



24

24

12



Summary

Introduction

Ecological Monitoring

Kinds of Monitoring

Effective Monitoring

Importance of Monitoring

Let's Get Technical

Citizen Science

Monitoring & Evaluation

Summary

Q&A

- Question-driven monitoring
- Conceptual models
- Appropriate data collection methods
- Citizen Science
- Monitoring and Evaluation
- Ecological concepts relevant to restoration projects

A minimum standard of monitoring for small, volunteer projects is the use of photo points, along with species lists and condition descriptions. (Note that photographic and formal quantitative “before and after” monitoring is ideally undertaken not only at the restored site but also at untreated areas and any actual reference site.)

Checklist of the characteristics of successful monitoring


Characteristic 1—Fit for purpose
Based on its purpose and objectives, the monitoring design has chosen:

- sound statistical principles
- an accurate and useful conceptual model
- relevant and answerable questions
- relevant and measurable entities to monitor
- sound data collection methods
- an appropriate scale of operations.

Characteristic 2—Early use of data to examine its properties and test assumptions
Historical and early-collected data are examined to understand normal variability, to aid in identifying new trends or errors.

Characteristic 3—High level of data curation and management
A comprehensive data management plan has been developed. Data are kept secure, and issues of future compatibility have been considered. Data are understandable to others. Field protocols, other methodology and metadata have been documented. Data publishing tools and data portals have been used to best advantage.

Characteristic 4—Communication of lessons learned and outcomes generated
The results of ecological monitoring are:
published in peer-reviewed journals and presented to the scientific community in conferences
communicated to the public and government through the media, public information publications and websites, and presentations.


25

25

Q&A

Ecological Monitoring for Successful Restoration











Mark Vergara
Principal Environmental Consultant
Acacia Environmental Management
mark.vergara@acacia.cc

01 October 2020

26