Landscape Function Analysis

Field Guide

Guidelines for Application in Mine Sites and
Land Rehabilitation Projects in the Philippines

Contents

Foreword
From the Secretary
Department of Environment and Natural Resources

A successful mining industry spells significant contribution to economic upswing. To top this, we are looking at responsible mining to open the door to a sustainable, productive and wholesome natural resource use. To champion this cause, the Department of Environment and Natural Resources (DENR) is keen in ensuring that landscapes affected by mining activities are restored to a stable and self-sustaining state.

With encouraging headways, adoption of rehabilitation technologies in mining companies should further gain ground. But more than this, the DENR must also keep ahead in setting the pace by looking at science-based monitoring systems that can ensure quick, reliable information for better management and timely decision making.

Currently, there is a need for common measures of success or progress of rehabilitation efforts in mining, forestry and other development projects that disturb landscapes. This is where Landscape Function Analysis (LFA) comes to fore. LFA is a monitoring procedure which can compliment existing ENR monitoring systems particularly in degraded mining areas.

LFA is based on accumulation of knowledge and experiences of leading landscape ecologists around the world. It has been applied in varied environmental conditions and have assisted in reaching rehabilitation agreements between regulators and industry land users with high degree of completion and success. LFA can contribute to existing methods and it does not intend to replace the current system being used in the country.

I congratulate the Project Team and the people who pursued the completion of this Project on Addressing Biodiversity Degradation in Co-Located Forestry and Mining Projects in the Philippines, from which the LFA is a major component. My utmost appreciation goes to the Australian Agency for International Development – Public Sector Linkages Program and the Commonwealth Scientific and Industrial Research Organization for introducing and funding this Project.

Steadfast in its mission, the Department wishes to open dialogue among all government and private sector stakeholders in exploring ways of encouraging growth and development of both the industries and our natural resources. I now invite our stakeholders through this Field Guide and Guidelines on Landscape Function Analysis to give an open mind to the application of the procedure in Philippine mining sites.

RAMON JP. PAJE
Secretary, DENR

Message
From the Bureau Directors
Department of Environment and Natural Resources

We, the Directors of the different Bureaus of the Department of Environment and Natural Resources, are very grateful to the Australian Agency for International Development – Public Sector Linkages Program and the Commonwealth Scientific and Industrial Research Organization for introducing and funding the Project on Addressing Biodiversity Degradation in Co-Located Forestry and Mining Projects in the Philippines.

The Project, which aims to assist in building the combined capabilities of the DENR Bureaus towards the development of a common system for gathering, processing and reporting relevant field data and information for the sustainable management of above-ground biological resources in co-located mining and forestry projects, will assure the availability and sustainability of the country's natural resources through judicious use and systematic restoration.

The major component of the Project is Landscape Function Analysis (LFA) which is a monitoring procedure to assess how well a landscape is working as a biophysical system. The introduction of LFA can give reliable information on the effects of disturbance on any landscape, such as mining areas. LFA can be a significant factor in forest restoration of key biodiversity areas and in final rehabilitation of mined-out areas in the Philippines.

We extend our congratulations to the Project Team and to the people behind this Project in promoting protection and rehabilitation of our environment.

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Message
From the Chancellor
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Rehabilitation and restoration of mined-out forest and degraded forestlands are global environmental challenges confronting both developed and developing countries. With global threats to the forests, coming from both natural and man-made sources, restoration of ecosystem functions will insure sustainable flow of ecosystems goods and services. Successful management of rehabilitation programs is by and large dependent on the ability of the managers to track the progress of rehabilitation works and identify constraints to the interventions employed.

The innovative monitoring procedure of the Landscape Function Analysis (LFA) or Ecosystems Function Analysis (EFA) provides quick, reliable and objective information useful for rehabilitation managers, site managers, or even decision-makers. Unlike current or traditional monitoring tools, the indices generated by the LFA tool such as stability, infiltration and nutrient cycling are key parameters towards determining the self-sustainability of the sites being restored particularly in its early stages.

The objectivity and rapid assessment features of the tool make it very attractive and valuable for the decision-making process like for example in altering its current inputs or strategies for restoring disturbed sites. Applied on a regular basis, the tool could graphically chart the rehabilitation trajectory and show if the interventions are hastening the restoration process or if additional inputs are required to achieve sustainability similar to an analogue or reference site.

Thus, LFA could likewise be significant in deciding the point where rehabilitation intervention could be terminated and left to nature itself.

The University of the Philippines Los Baños takes pride in being part of this inter-disciplinary team which piloted the LFA/EFA monitoring tool in six (6) mining sites around the Philippines and has come up with this useful Field Guide for the use of rehabilitation practitioners, managers, monitoring teams, researchers, teachers and even students. The University highly recommends its adoption by government environmental regulators to improve on its monitoring ability and decision-making process particularly for mining projects and other forest rehabilitation programs.

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Acknowledgement

Production of this field guidebook was made through the AUSAID-PSLP/CSIRO-funded Project entitled: Addressing biodiversity degradation in co-located mining and forest development projects in the Philippines. The following institutions and individuals collaborated and have made significant contributions towards the production of this material, namely: The Australian Government through the Public Sector Linkages Program (PSLP) of the AUSAID (Australian Agency for International Development) for the financial support to the project; The Commonwealth Scientific and Industrial Research Organization (CSIRO) for spearheading the proposal preparation and the overall management and administration of the project activities as well as counterpart funds and personnel; Mr. David Tongway, Honorary Fellow CSIRO, the developer and guru of the LFA/EFA tool for personally training local participants on the theory and practice of LFA/EFA. He has likewise been continuously mentoring participants even after the formal training through emails which has greatly improved the skills of these people; the heads of the collaborating institutions: the Department of Environment and Natural Resources and its attached bureaus: Ecosystems Research and Development Bureau (ERDB) the lead organization, Environmental Management Bureau (EMB), Forest Management Bureau (FMB) and Biodiversity Management Bureau (BMB, formerly PAWB); and the University of the Philippines Los Baños. Recognition is likewise appropriate to the six (6) mining companies who have opened up their sites for the setting up of monitoring transects/plots of the LFA procedure in the Philippines. These companies through their heads, managers and staff have regularly accommodated and supported the research team in their field works and monitoring: Holcim Philippines (Norzagaray, Bulacan), Rio Tuba Nickel Mining Corporation (RTNMC, Rio Tuba, Bataraza, Palawan), Carmen Copper Corporation (CCC, Toledo City, Cebu), Bohol Limestone Corporation (BLC, Garcia Hernandez, Bohol), Taganito Mining Corporation (TMC, Taganito, Claver, Surigao del Norte) and Pacific Cement Corporation, Inc (PACEMCO, Surigao City).

Photo credits to the following individuals: Mr. Aljoy H. Abarquez, CSIRO, Dr. E. L. Tolentino, Jr. UPLB, For. Paul Cuadra, ERDB, Mr. Lauro B. Rueda, ERDB. For. Patrick Anthony M. Calalo, UPLB.

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Abbreviations and Acronyms

AusAID	Australian Agency for International Development
BLC	Bohol Limestone Corporation
BMB	Biodiversity Management Bureau
CCC	Carmen Copper Corporation
CFNR	College of Forestry and Natural Resources
CSIRO	Commonwealth Scientific and Industrial Research Organization
DAO	Department Administrative Order
DENR	Department of Environment and Natural Resources
ECC	Environmental Compliance Certificate
EIS	Environmental Impact Statement
EFA	Ecosystem Function Analysis
EMB	Environmental Management Bureau
EPEP	Environmental Protection and Enhancement Program
ERDB	Ecosystems Research and Development Bureau
EO	Executive Order
FMB	Forest Management Bureau
FMRDP	Final Mine Rehabilitation and Decommissioning Plan
FMRP	Final Mine Rehabilitation Plan
LFA	Landscape Function Analysis
LOI	Landscape Organization Index
MGB	Mines and Geosciences Bureau
MMP	Maintenance and Monitoring Plan
MMT	Multipartite Monitoring Team

MPSA	Mineral Production Sharing Agreement
MRF	Mine Rehabilitation Fund
MRFC	Mine Rehabilitation Fund Committee
PACEMCO	Pacific Cement Philippines, Inc.
PCQM	Point-Centered Quarter Method
PSLP	Public Sector Linkages Program
RTNMC	Rio Tuba Nickel Mining Corporation
SSA	Soil Surface Assessment
TMC	Taganito Mining Corporation
UPLB	University of the Philippines Los Baños
WQM	Wandering Quarter Method

1 Introduction

The 1987 World Commission on Environment and Development (Our Common Future) report defined sustainable development as "development which meets the needs of the present without compromising the ability of future generation to meet their own needs."

Sustainable rehabilitation of all disturbed landscapes, including mine sites and forest land, is a national priority of the Philippines. Mining permits and lease conditions are being given with the proviso that those who use land for utilization of resources therein will also be fully responsible for the conservation, protection and restoration of sustainable landscapes upon completion of their development projects.

Landscapes disturbed by or during mining, forestry and other development projects will need to be rehabilitated back to sustainable and functional state for the safety and protection of current generations as well as the use by future generations.

To ensure adherence to this principle and priority will require an effective assessment and monitoring system that will aid policy makers and decision makers at all levels. Landscape Function Analysis (LFA), also referred to as Ecosystems Function Analysis (EFA), was developed at the CSIRO Australia as a cost-effective tool for examining or monitoring key indicators of landscape status and/or changes. LFA has been widely used in sustainable management of rangelands, monitoring mine-site rehabilitation, and restoration of natural forests or vegetations in many countries around the world since its development in the 1980s. Mining operations in Australia use LFA to aid in the restoration of sustainable post mining landscapes and has resulted to recent return of mining bonds.

This Field Guide and Guidelines summarizes the principle, concept and step-by-step guide for practitioners on how to use LFA as an assessment and monitoring procedure for disturbed landscapes such as in mining, forest land and as well as in disaster areas. This guide will be useful for DENR monitoring teams, Multi-Partite Monitoring Team (MMT), researchers, teachers and students of forest rehabilitation.

LFA can contribute to existing methods and it does not intend to replace the current system being used in the country. It fills the gap or lack of agreed standards to use between regulators and stakeholders. Overall, LFA offers a promising, practical and clear measure of rehabilitation success.

This Field Guide and Guidelines is a practical summary of the manual on Landscape Function analysis published by the CSIRO Australia and is available at http://ovcre.uplb.edu.ph/downloads/category/24-landscape-function-analysis.

2 Landscape Function Analysis

2.1 THE CONCEPT

Landscape Function Analysis (LFA) is an approach that "deals with ecosystems in terms of processes involved in the transport, utilization and cycling of scarce and limiting resources, such as water, topsoil, organic matter and propagules, in space and time" (Ludwig et al., 1997, Whisenant 1999, Tongway and Hindley 2004).

Briefly, LFA assesses the movement and organization of resources (such as soil, water, nutrients and plant community) across the landscape to probe the stability, nutrient cycling and infiltration (or ability to store resources) characteristics of landscapes to determine their functionality and self-sustainability. LFA can assess these indicators using simple and practical procedures that can be completed while on site. No laboratory procedures are necessary.

Indicators of LFA can be used to assess the functional status of a given landscape in comparison to a desired (or analogue) landscape function or condition. When plotted through time, LFA indices will show progress being achieved by management interventions on rehabilitation of the landscape.

Methodology for LFA includes:

- observation of the landscape to project the flow of resources (i.e. water, soil and litter) during overland flow

- identification of sections within the transect: parts which can capture and parts where resources can be displaced from
- assessment of soil surface within the identified sections by the use of indicators
- data forms or spreadsheet (in MS Excel) for automatic computation

Numerical values for landscape stability, infiltration and nutrient cycling will be readily computed once data has been inputted into the spreadsheet. These values can be used to compare the similarities and differences in landscape function of sites being compared or to show progress or changes through time.

2. 2 APPLICATIONS

LFA is a simple, cost-effective way of assessing sustainability of landscapes. It can be used as a diagnostic tool to compare the status of one landscape with another, and/or to provide evidence on the rate and trend of recovery occurring on disturbed landscapes and as influenced by management interventions. LFA can also be used to determine whether the landscape is progressing towards self-sustainability or functional state, or retrogressing to deeper dysfunction.

Although first developed for arid and semi-arid rangeland management, LFA has been adapted in mine site and degraded land rehabilitation in extreme environments from deserts to wet tropics. LFA indices, represented in easy to understand numerical values (from 1 to 100), facilitates communication across levels of organizations and including with policy makers, the public in general and media practitioners.

LFA can be used for estimating the amount of management interventions needed to improve the landscape functionality of one site to a desired state. As a rapid assessment tool, LFA can be used on a more regular basis to assist continuing rehabilitation efforts and at lower cost.

Progress of landscape function development using LFA is normally monitored on regular period, preferably at the same season of the year, and continued until the goals and objectives of landscape rehabilitation has been reached.

3 Field Guide on LFA Methodology

3. 1 LFA ACTIVITY FLOW CHART SUMMARY

Steps	Description
Preparing for LFA field assessment	Gather background information and materials about the area to be assessed in order to understand the objectives and intention of the assessment. From the information and materials above, identify the areas to be assessed. Prepare the tools and equipment (see list in Appendix 1). Prepare necessary permits including travel itinerary and work schedule. Prepare measures to protect the Health, Safety and Environment for all involved.
Site Description (FORM 1)	On arrival to the area, gain familiarity to the geographic setting of landscape being assessed by filling out the Site Description Data Sheets for each block of land to be assessed. Confirm or adjust the sampling points or transect positions as needed.
Landscape Organization Assessment (FORM 2)	Assess the patch/inter-patch sections along the transect line and their types. Measure the patch width (perpendicular distance at both sides of transect line).
Soil Surface Assessment (FORM 3)	Select 3 examples of each patch and inter-patch type and test against the 11 different soil surface assessment indicators. Assess other specific erosion features.
Vegetation Assessment (FORM 4)	Assess vegetation structure and composition using Wandering Quarter or Point-Centered Quarter Method as described in the LFA Manual.
Data entry, analysis and report submission	All field data must be immediately entered into specific spreadsheets designed for each section of the LFA procedure. Write down key observations while on field or site. Address needs for corrections or verification of data. Prepare and submit the report.

3.2. PREPARING FOR LFA FIELD ASSESSMENT

3.2.1 Collect background information about the site being assessed or monitored

Understand the objectives or intention of the field assessment work to be done. In assessing a mine rehabilitation project, for example, understand the rehabilitation plan and management interventions as described in the Environmental Protection and Enhancement Plan (EPEP) and Final Mine Rehabilitation and Decommissioning Plan (FMRDP) which will include copies of maps, lay-out of the land, rehabilitation schedule and any relevant reports.

State clearly the objective of the field assessment based on the understanding of the aim and intention of the assessment and the conditions of the site. Examples of assessment objectives could be "to measure the progress of landscape function development since start of the rehabilitation project and in relation to the agreed analogue site" or "to compare the effectiveness of management inputs on landscape functionality in one rehabilitation site to another."

3.2.2 LFA tools, equipment and data collection forms

Tools and Equipment

Check that all tools and equipment needed to do an LFA assessment are ready and are in good working conditions. The list of tools and equipment for LFA assessment is in Appendix 1, page 61.

Data Collection Forms

There are 3 basic forms for each stage of the LFA procedure namely: Form 1 Site Description (Appendix 2), Form 2 Landscape Organization (Appendix 3) and Form 3 Soil Surface Assessment (Appendix 4). Form 4 Vegetation Assessment (Appendix 5) may not be needed if vegetation has not been established in the landscape. Each Form is designed for each stage of the LFA procedure.

LFA field data can be recorded using the reprinted forms or keyed-in directly on to the electronic version of the form in MS Excel spreadsheets loaded on a laptop computer or a tablet. Each form corresponds to a separate spreadsheet tab in the electronic file and linked to compute the LFA indices automatically. All these forms are included in one electronic file and ready for use (http://ovcre.uplb.edu.ph/downloads/category/24-landscape-function-analysis).

IMPORTANT: Key-in the data only on the designated cells of each form to avoid corrupting the formulae in the system (in protected cells).

Data recorded in reprinted form can be keyed in at the end of each work day. Doing so will contribute to report preparation while on field and also allows the crew to confirm any data anomaly or observation while fresh in mind, the next work day or before returning back to base.

Keying the data directly in to the spreadsheets on a computer allows immediate verification of the data against field observations while on site (the LFA indices are automatically recalculated as each data is keyed in to the spreadsheet).

3.2.3 Permits and travel arrangements

Prior to leaving the base or office, prepare written work schedule and travel itinerary including transportation, accommodation arrangements and contacts or communication arrangements.

Secure all necessary permits to access the area to be assessed with appropriate area manager.

Identify all hazards and set up necessary measures to mitigate all risks to health, safety and environment for all involved in the assessment activity.

Advise as necessary the local police, military and other public security units concerned about your presence in the areas to be assessed.

Copies of these documents must be made accessible to your designated base contact person and the manager of the area to be assessed.

3.3 SITE DESCRIPTION

On arrival to the site, gain familiarity of the layout or geographic setting of the landscape (or watershed catchment) being assessed using the map. Go through or around the area when possible.

The Site Description data sheet (Form 1, Appendix 2, page 62) is used to record the general description of the landscape being assessed.

Write down as many detailed observation to describe the site. Interview the site manager and other personnel actively involved in the rehabilitation of the landscape to understand the situation surrounding the rehabilitation project.

It is best to complete this form before proceeding further. However, feel free to add more notes and observations to this form which may come up during the assessment of the landscape.

Guidelines for transect selection in LFA

Walk around the landscape to be assessed to gain a closer perspective of its status. Identify and locate the variations across the landscape to map homogenous landscape units of the whole land being assessed. The size of the landscape and the amount of variations within it contribute to the number and location of transects to be used for the assessment.

In most cases, aim to have at least 2 or 3 transects to represent the landscape being assessed; add as needed depending on the size and characteristics of the landscape. For very large landscapes, prefer to subdivide the area into smaller homogenous landscape units and take LFA data to describe each unit.

The transect direction should be laid out following the gradient direction or flow of resources across the landscape (i.e., downhill or towards a watering hole) that most affects vegetation distribution. If the flow of resources bends or changes direction, the transect line should follow this by also bending at the turning point of resources flow direction.

Permanent markers, painted with highly visible coloured paints, on the ground are used to easily re-locate transects start, end and bends during subsequent re-assessments of the landscape.

When comparing progress of rehabilitation in two sites, e.g., two sites with different rehabilitation approach, or a rehabilitation site against an analogue landscape (a landscape with higher level of ecological functionality), aim to position transects in as closely similar physiographical aspects (i.e., slope, soil type, soil composition and elevation) as possible.

The analogue landscape should be the best representation of the final condition of the landscape upon completion of the rehabilitation project. This is usually an undisturbed site, but in its absence a site with similar conditions (slope, elevation, soil) to the selected transect but exhibits a functional and self-sustaining state could be designated as analogue or reference site.

3.4 LANDSCAPE ORGANIZATION ASSESSMENT

Highly functional landscapes are able to conserve efficiently and effectively utilize the soil, water and nutrients (resources) within their extent in order to attract and support life. By contrast, landscapes that are dysfunctional tend to lose these material resources and tend to less likely attract life. Assessment of how a landscape can capture and regulate these material resources is pivotal to understanding how that landscape is progressing towards self-sufficiency and becoming a functional landscape.

Ability of a landscape to capture and regulate these materials can be assessed by taking measurements of the patches and inter-patches of resource accumulation across the landscape. Patches (or fertile patches) are where resources tend to accumulate, have enhanced soil properties (infiltration, nutrient cycling and stability). Inter-patches are where resources flow freely (tend to poorly regulate resources) and have poor soil properties than patches.

The objective of assessing Landscape Organization is to characterize and map the landscape being assessed in terms of the spatial pattern of resource loss and accumulation.

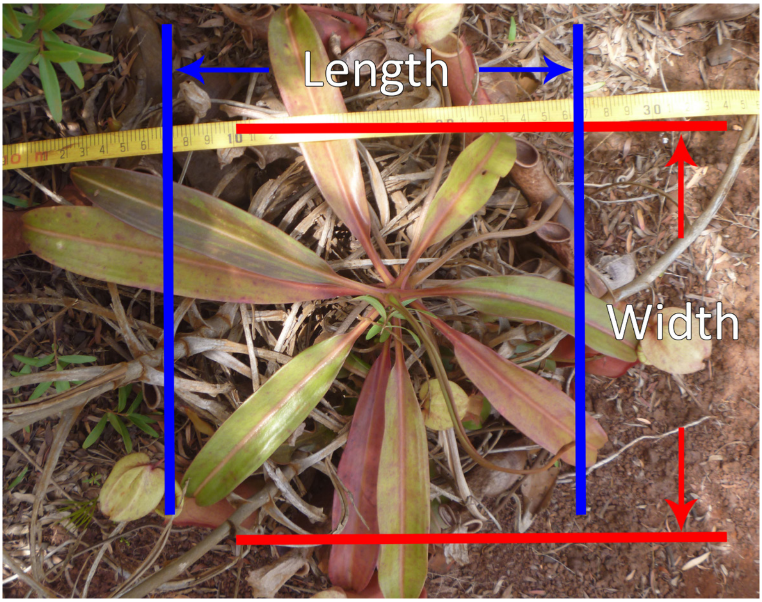
To characterize the landscape being assessed measure the following parameters:

a. The quantity (number) of obstructions to overland flow per unit length of transect line
b. The width of obstructions per unit length of transects
c. The mean distance and range between obstructions (inter-patch length) per unit length of transect

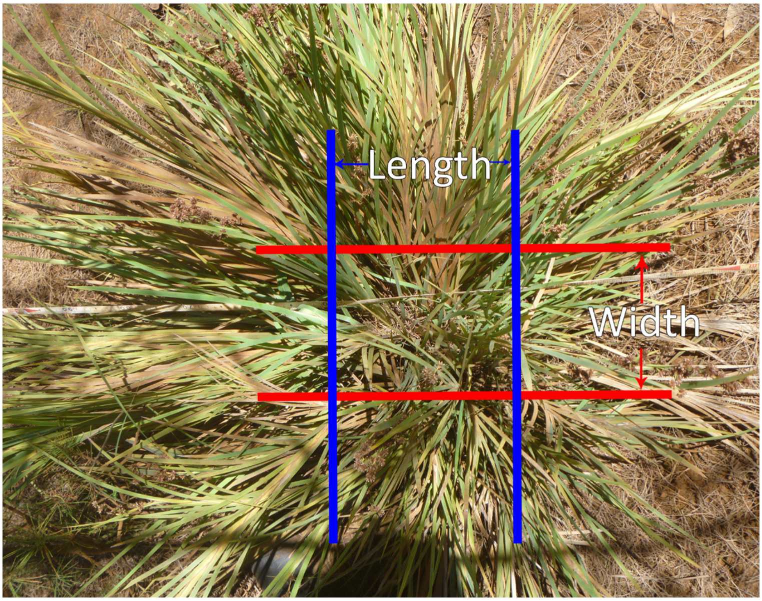
Measure (in meter units) the length (i.e., start and end) of each patch and inter-patch along the transect line, then measure (in centimeters) the width of each patch perpendicular to the transect line. Do this for all patches along the transect line or at least up to 6 repeats of the patch and inter-patch pattern. Take photos looking down the transect line to show general perspective of the landscape, including any specific observations along the transect line.

Figure 1. Patches and inter-patches along a transect line. Downslope is from left to right. Yellow numbers denote patches while blue numbers are inter-patches.

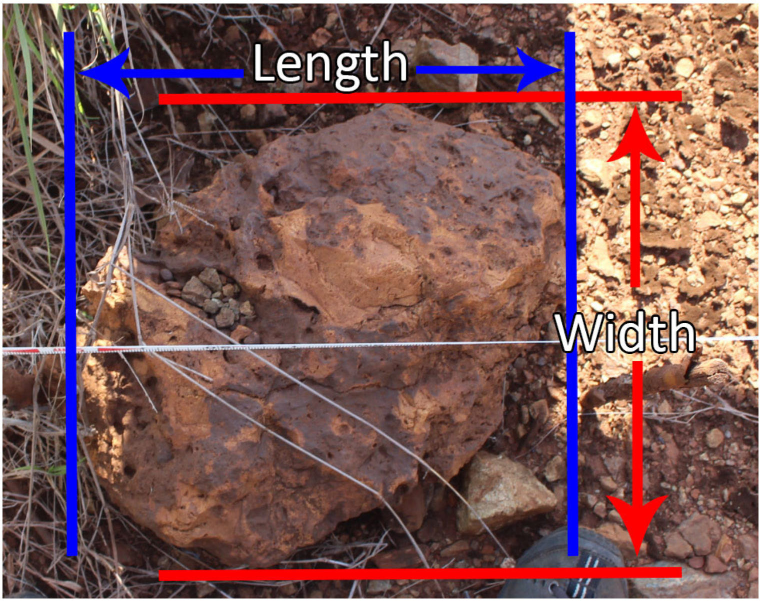
Figure 2. Sample photos showing measurements of patch width and patch length of different patch types.



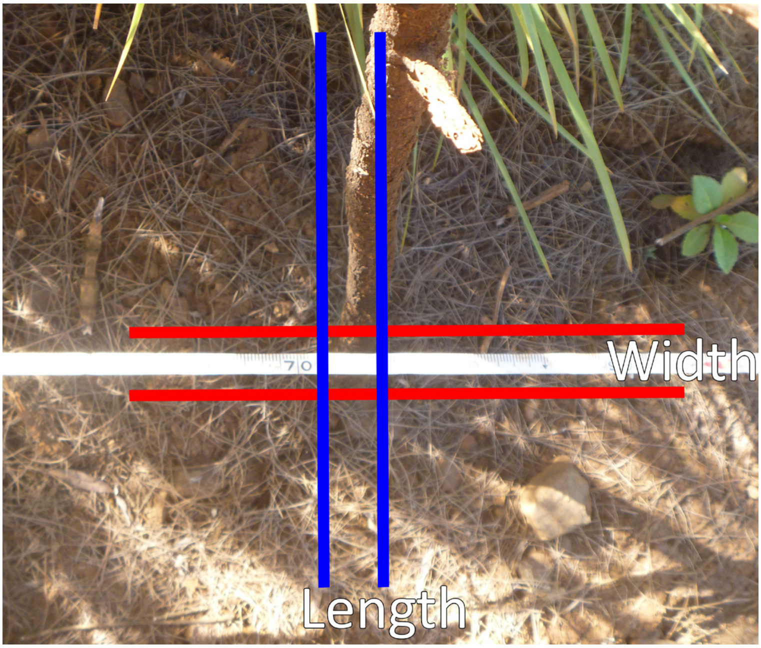
a. Small shrub patch



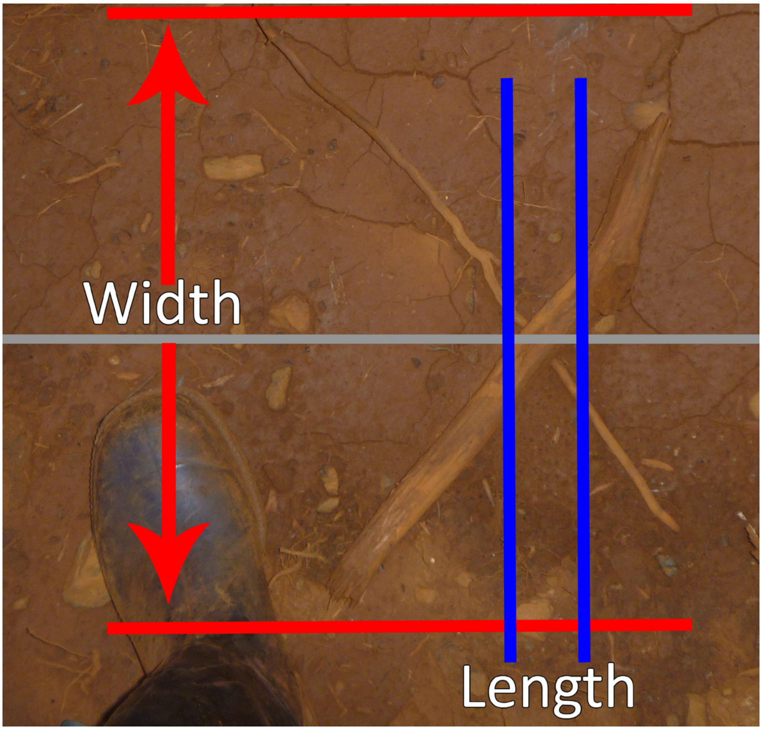
b. Grass patch



c. Rock patch



d. Tree patch



e. Branch patch

Figure 3. Examples of patches and interpatches as labeled from a-f.

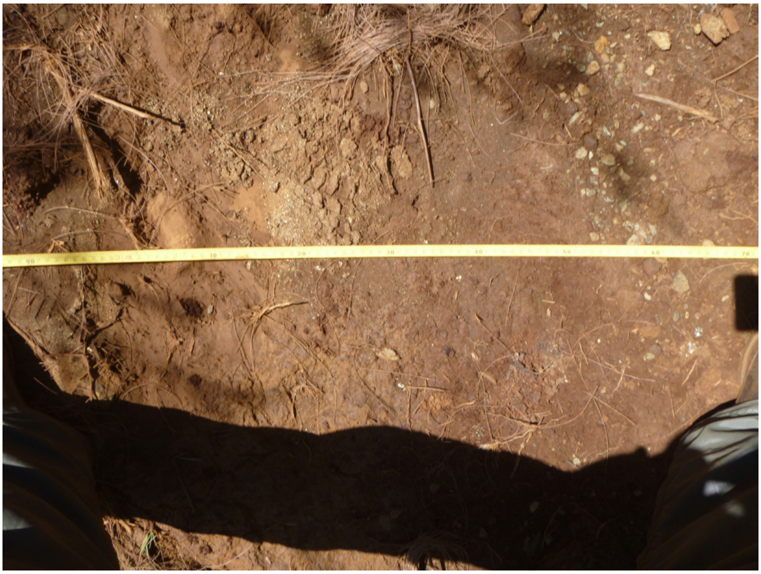
a. Grass patch

b. Tree grass patch

c. Branch litter patch

d. Rocky patch

e. Stony soil



f. Bare soil

Record the data on to Form 2, or directly on the Excel spreadsheet (LFA_SSA_data_entry.xls) – (http://ovcre.uplb.edu.ph/downloads/category/24-landscape-function-analysis). Below are examples of how patches are identified and their measurements entered into Form 2 Landscape Organization data sheet (Table 1).

Table 1. An example of a completed Form 2 (landscape organization) data sheet for a naturally regenerated quarry area in Bohol Limestone Corporation, Bohol.

Transect: -	**Transect 1**		
Distance (m)	**Patch Width (cm)**	**Patch/ Interpatch Identity**	**Comments**
0			
0.20	8	GC	Grass Complex
0.30		RL	Rocky Litter
0.55	55	GC	
1.50		BR	Bare Rocky
1.85	10	GC	
4.75		BR	
5.85	65	GC	
6.95		RL	
7.10	10	SP	Shrub Patch
8.70		RL	
9.80	160	GC	
10.35		RL	
12.00	80	GC	
13.30		RL	
13.80	25	GC	
20.50		RL	**Surface is Hard Limestone**
20.70	10	GC	
21.30		RL	
21.36	9	GC	
22.95		RL	
23.50	19	GC	
24.70		BR	
25.00	13	GC	

TIP: In mature ecosystems where ground cover is continuous (i.e. patches and inter-patches cannot be clearly defined), classify the cover as one patch.

3.5 SOIL SURFACE ASSESSMENT

3.5.1 Rain splash protection (soil cover)

Vegetation and other materials (i.e. rocks) cover protect the soil from rainsplash type erosion. Percent protection cover is assessed through this indicator.

Exceptions to the assessment:

- Annual plants
- Vegetation litter (because a separate indicator shall assess this – Litter Cover and Origin)
- Leaves/Branches >0.5m (with elevation >0.5m from the soil surface of the query zone being assessed)

Class 1 = < 1% cover
Bare soil inside the query zone. Virtually no rainsplash protection.

Class 2 = 1% - 15% cover
Some perennial vegetation and rocks cover 1-15% of soil surface. These provide a small degree of protection from rainsplash erosion.

Class 3 = 15% - 30% cover
Small rocks > 2cm diameter and perennial vegetation cover a fraction of the query zone. These provide moderate protection from rainsplash.

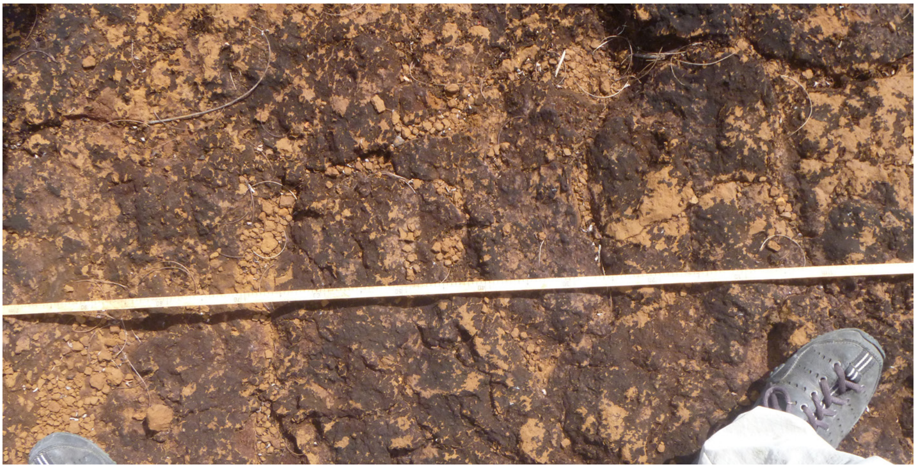
Class 4 = 30% - 50% cover
Small rocks (diameter>2cm) are densely covering the query zone. The rocks provide high soil protection from rainsplash erosion.

Class 5 = > 50% cover
Grass patch covers > 50% of query zone. These provide very high rainsplash protection.

3.5.2 Perennial vegetation cover

This indicator primarily assesses how much belowground biomass (root) is present in the query zone. The score is centered on percent basal cover based on vegetation. Detailed explanation on how to conduct this is shown in the LFA Manual .

Excluded from assessment:
• Annual plants



Class 1 = < 1% basal cover
No perennial vegetation is present.

Class 2 = 1% - 10% basal cover
Less than 10% perennial basal cover.

Class 3 = 10% - 20% basal cover
Query zone being assessed is from arrow to rightmost part of the picture. Area occupied grass (butt) is up to the yellow line—about 18-20% of the query zone.

Class 4 = > 20% basal cover
Query zone being assessed is in between the red flags. Grass butt lengths constitute about 50-80% basal cover.

3.5.3 Litter cover, origin and decomposition state

Litter cover

Percent litter cover (plant and animal) as well as annual plant cover are assessed in this indicator.

A single combined score consisting of litter cover, origin, and stage of decomposition is recorded.

For example, 55% litter cover (Class 4) with local origin and nil decomposition stage is entered as 4ln in the SSA field data sheet and in the LFA spreadsheet.

Class 1 = < 1% - 10% cover
Virtually no litter cover.

Class 2 = 10% - 25% cover
Approximately 16% litter cover.

Class 3 = 25% - 50% cover
Litter cover is more than 25% but is less than 50%.

Class 4 = 50% - 75% cover
About 70% litter cover.

Class 5 = 75% - 100% cover
Approximately 90% litter cover.

Class 6 = 100% cover, 0-20 mm thick
100% litter cover, but less than 20mm thick.

The class is assigned according to the following depths of litter present:

- 21-70 mm (Class 7)
- 70-120 mm (Class 8)
- 120-170 mm (Class 9)
- >170 mm (Class 10)

Litter origin

The objective of the assessment is to observe whether litter in the query zone has been transported or not.

Local origin (l) - Litter under Acacia sp. Stand
No signs of transport can be observed (i.e. intact forest/ stand floor).

Transported Origin (t) - Litter may or may not be from existing vegetation
Shows clear signs of being transported to the query zone by erosion/run-off.

Litter Incorporation

Nil decomposition (n)
Few signs of decomposition and incorporation into the soil

Slight decomposition(s)
Little signs of decomposition and incorporation into the soil; some breakdown into fragments is evident.

Moderate decomposition (m)
Some evidence of fungal presence along with breakdown of fragments.

Extensive decomposition(e)
Soil is darkened up to several centimeters deep due to massive litter incorporation into the soil.

3.5.4 Cryptogam cover (biological crust)

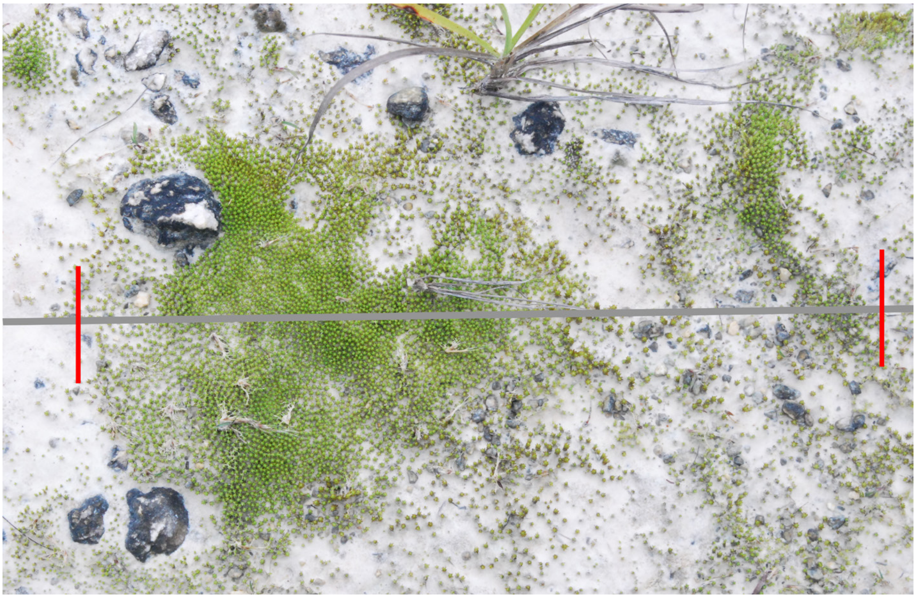
This indicator assesses the contribution of the biological crust (if present) to the landscape function. Presence of lichens, algae or fungi on the soil surface and their percent cover are observed.

Not applicable (Class 0) if:
- Soil is sandy or no stable crust is observed
- Soil surface is under dense litter cover (i.e. intact secondary forest floor)

Class 1 = < 1%
No contribution, but sufficient stable crust is present for cryptogams to establish.

Class 2 = 1% - 10%
Slight contribution about 8-9% cover.

Class 3 = 10% - 50% cover
Query zone being assessed is in between red lines. Moderate contribution of cryptogam (dark color) about 40% - 50% cover.



Class 4 = > 50% cover
Extensive contribution of cryptogram (green) with > 50% cover.

3.5.5 Crust brokennes

This indicator is assessed by observing how broken the crust is.

An example of crust scraped from the soil surface.

Scored as Class 0 (not applicable) if:

- No crust is present; loose or sandy soil surface
- Soil surface is composed of self-mulching soils (i.e. self-mulching clays).
- Soil surface is under dense perennial litter cover (i.e. intact forest floor)
- Crusted area of the query zone is < 25%

Class 1 = Large polygonal cracks which exhibit curling. Extensively broken.

Class 2 = Crust is partially stable while curling of polygonal cracks are evident. Moderately broken.

Class 3 = Some parts of the crust are missing exposing underlying stones. Cryptogram growth shows that parts of the crust left behind are stable. Curling of polygonal cracks is not evident. Slightly broken.

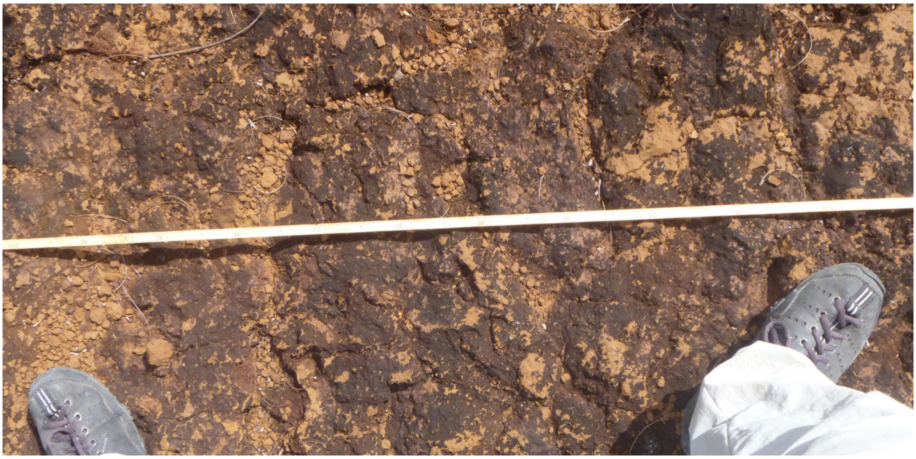
Class 4 = Some polygonal cracks evident but with no curling of edges.
Intact, smooth crust.

3.5.6 Soil erosion type and severity

Erosion occurrence in the query zone is assessed in this indicator together with its type and severity. A diligent observation for signs of erosion is of primary importance.

The five types of erosion are described:

Sheeting (E). Gradual removal of topsoil (Ao) layer . Stones and rocks represent the "lag" left behind after active sheeting.



Scalding (S). Complete loss of topsoil layer exposed the very hard sub-crust which is almost impermeable to water infiltration.

Rills and Gullies (R). Result of large volumes of flowing water isolated in continuous soil surface depressions and are usually > 30 cm deep. A separate assessment (using the Rill Assessment Data Sheet, Appendix 6, page 67) needs to be done when either or both are present in the transect.

Pedestalling (P). Unstable soils where topsoil has been removed up to several centimeters deep. This is often represented by the presence of soil pedestals which were protected from erosion by overlying rocks or leaves.

Terracettes (T). Moderate terracing of highly erodible soil.

Table 2. Example table recording soil erosion type and severity

SEVERITY	Insignificant	Slight	Moderate	Severe
EROSION TYPE	Class	Class	Class	Class
Sheeting (E)	4	3	n/a	n/a
Pedestal (P)	n/a	n/a	n/a	1
Terracette (T)	n/a	n/a	2	1
Rill (R)	n/a	n/a	2	1
Scalding (S)	n/a	n/a	n/a	1

3.5.7 Deposited materials

This indicator examines the presence of loose soil material (or litter) which is available for transport in the event of further erosion in the query zone being examined.

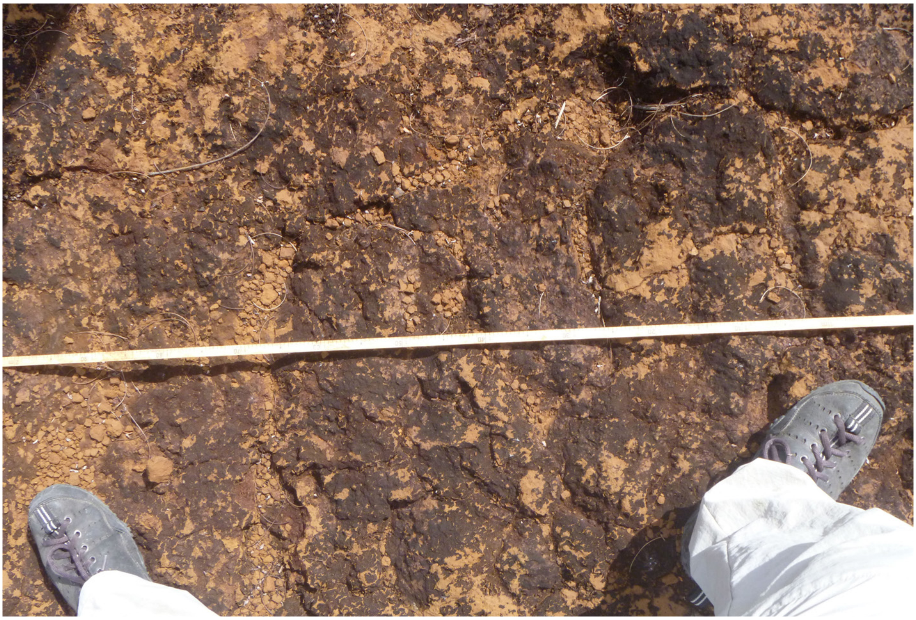
The following can be classified as deposited materials:

- Erodible materials on top of the crust (i.e. primarily soil or transported litter)
- Particles which are not from the immediate area or areas adjacent to the query zone

Class 1 = > 50% cover
Significant amount of deposited material (soil) has settled in the query zone and seems to be available for further transport by surface run-off; several centimeters in depth.

Class 2 = 20%-50% cover
A considerable amount of soil material has been deposited in this rocky patch; few centimeters in depth.

Class 3 = 5% - 20% cover
Small amount of fine soil material is available for transport in the event of erosion.



Class 4 = 0% - 5% cover
Very little amount of alluvial material inside the query zone (from toe to toe) is available for further erosion.

3.5.8 Soil surface roughness

Assessment of the smoothness or roughness (depth of depressions) of the immediate soil surface (including appendages, i.e. rocks) in the query zone. Depressions in the surface are (most of the time) considered as regions for resource capture within the landscape.

Class 1 = < 3 mm
Smoothly crusted soil surface; considerably very low resource retention.

Class 2 = 3-8mm (low retention)
Moderately rough surface due to stony surface but shows minimal signs of real resource capture.

Class 3 = 8-25 mm (moderate retention)
Moderate resource capture (limestone particles) by rocky/stony surface.

Class 4 = 25-100 mm (large retention)
Large amount of soil retained due to depressions made by rocks and parts where soil surface is elevated.

Class 5 = >100mm (extensive retention)
Large rocks in the query zone may provide retention for actual resource capture.
Query zone is from toe to toe.

3.5.9 Surface resistance to disturbances

This indicator presents how hard the soil surface is by knowing the strength of the force needed to break the physical surface.

Class 5 = Non-brittle
Soil under (but not limited to) an intact secondary growth forest with organic layer (O Horizon) characterized with springiness when pressed; may also be found in soils under dense perennial litter cover. High vegetation cover provide a dense belowground 'root mat'. Surface is "springy" when pressed; includes self-mulching clays. No physical crust.

Class 4 = Hard and/or brittle
Very hard surface due to complete removal of topsoil (exposure of vary hard subsoil); a metal implement is needed to break the surface. Not able to break surface using your fingers.

Class 3 = Moderately Hard
A plastic tool is needed to break the surface. Difficult to break surface using your fingers.

Class 2 = Easily broken
Easy to break surface using fingers up to the first knuckle joint.

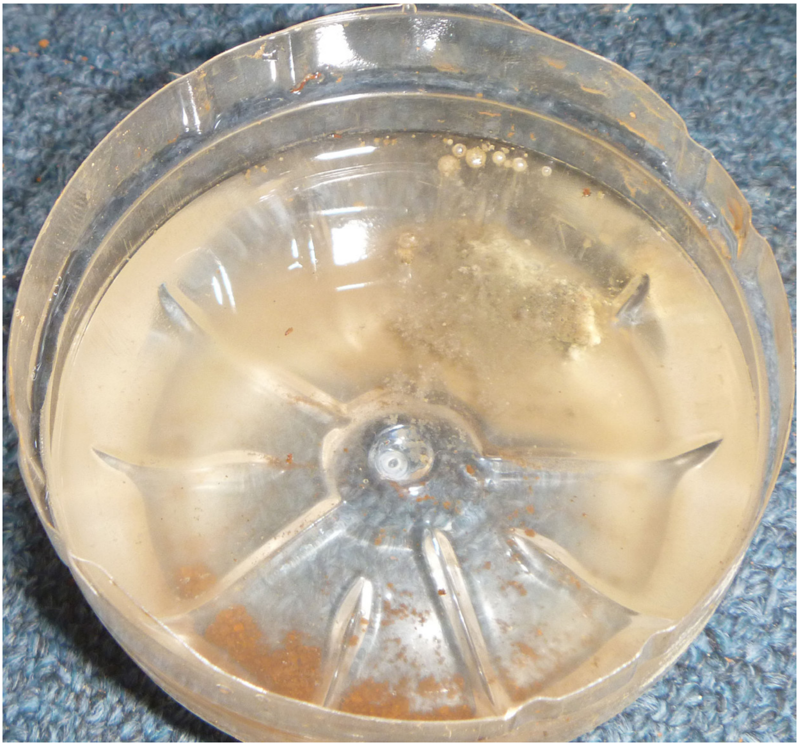
Class 1 = Loose Sandy
Typical sandy textured soil with no physical crust; Easy to break surface with a finger up to the second knuckle joint.

3.5.10 Slake test

Slake test or test for soil friability is an indicator of soil cohesiveness especially when wet. The assessment should be done with dry soil samples only.

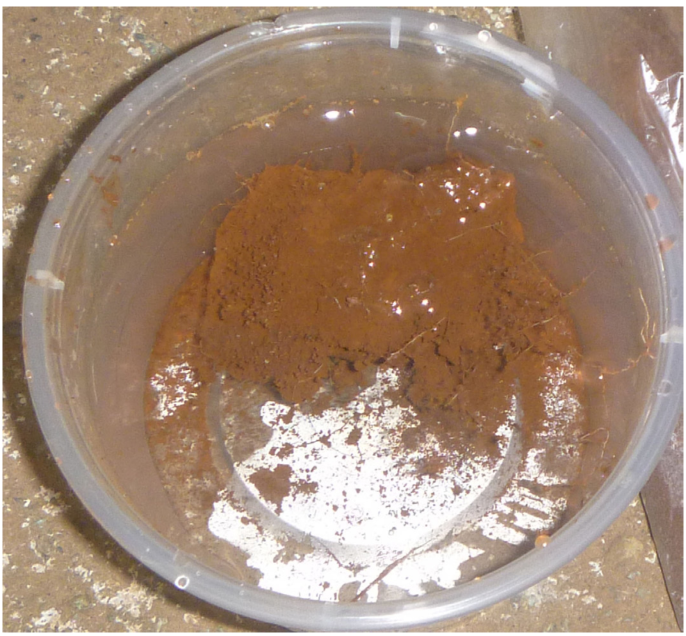
A soil fragment (at least 1cm x 1cm in size) is gently immersed in distilled or rainwater and response to wetting is observed for a period of time. Crust must be on top. Soils with high organic matter content may float in water, usually scored Class 4 (very stable).

Slake test is not applicable on sandy soils (Class 0).



Class 1 = Very unstable
Soil fragment disintegrates in < 5 seconds; very fine bubbles may emerge.

Class 2 = Unstable
Soil fragment goes slumping within 5-10 seconds.



Class 3 = Moderately Stable
Slumping of subcrust but most of the crust is intact.

Class 4 = Very Stable
No slumping of particles is evident after several minutes of being immersed in water; whole fragment remains intact with no swelling; large bubbles may emerge.

3.5.11 Soil texture

The indicator presented in this section is assessed by conducting the feel method for soil texture determination. The flowchart below shows the guidelines for assessing the soil texture. A soil bolus must be made from the soil sample gathered following the procedures below:

- Gather soil from 0-5 cm soil depth
- Get enough soil to fit the palm of the hand
- Add water accordingly in few amounts; kneed until a soil ball (bolus) is formed
- Add soil or water if necessary until an appropriate bolus is formed (bolus doesn't stick to the palm or fingers; coherent)

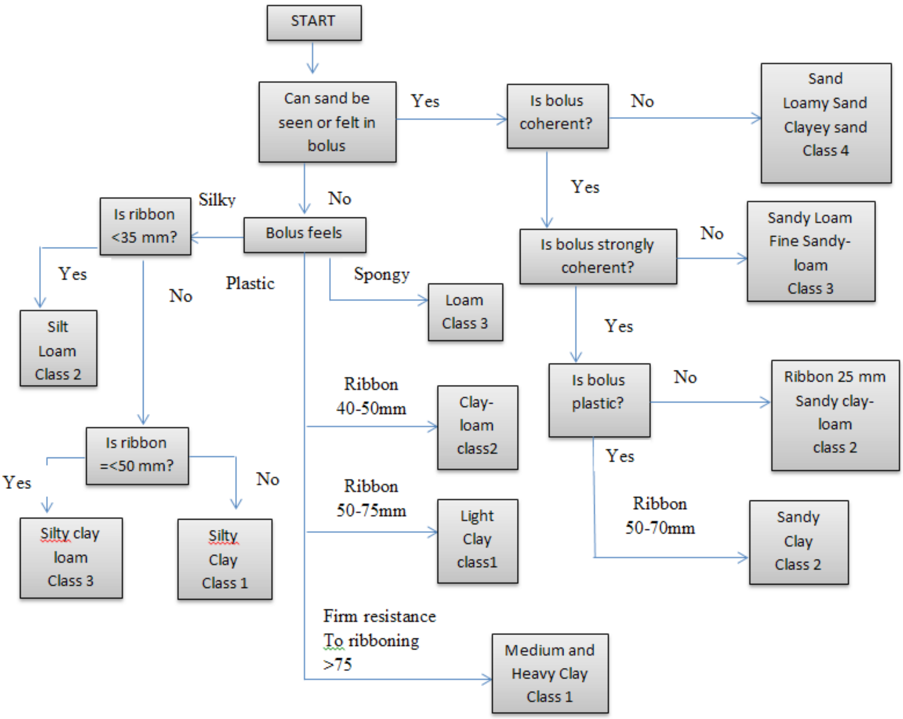


Figure 4. Soil Texture Flowchart

A ribbon is created by pushing the bolus through the thumb and forefinger to create a flattened tube. The length of this tube is indicative of the clay content of the soil (Tongway and Hindley, 2004).

These 11 indicators can be assessed on site following simple system that was designed based on accumulation of scientific research and understanding of landscape ecology over decades by landscape ecologists around the world.

The data from these 11 indicators can be grouped to generate three indices of overall stability, infiltration and nutrient cycling that describe the overall ecosystem function of the site being assessed.

The indices are automatically generated once the raw scores (written in Form 3) are inputted in the LFA spreadsheets provided in the LFA_SSA_data_entry.xls.

3.6 VEGETATION ASSESSMENT

Assessment of vegetation describes the functional and habitat complexity in the landscape and provides information on the status of landscape function development or recovery.

Advanced stages of vegetation cover can have very complex composition and structure. Assessing the grass, shrub and tree layers of vegetation in a landscape is practical enough for land managers.

There are two recommended methods for vegetation assessment, namely the Point-Centered Quarter Method (PCQM) and the Wandering Quarter Method (WQM).

Both methods are designed to assess the above-ground composition and structure that contribute to the ability of the landscape to accumulate and use resources towards reaching self-sustainability or balanced state. PCQM, however, is not recommended for assessing areas where vegetation has been established following standard planting intervals or regular spacing, for instance, in tree plantations.

Point-Centered Quarter (PCQM) method

PCQM involves establishing sampling points at regular intervals along the transect line. A minimum of 20 sampling points per transect line is recommended; which may not be possible on some situations, e.g., on very small landscapes being rehabilitated. The sampling points (Fig. 5) must be spaced to avoid overlaps and assessing the same plant on two sampling points.

Draw an imaginary line to demarcate each sampling point in 4 directions or quadrants. Measure the distance to the nearest plant of interest for each strata of vegetation. Measure the above ground vegetation parameters (i.e. total tree height, height to foliage, crown width and breadth, and canopy density) in Form 4, Appendix 5, page 65.

Wandering Quarter Method (WQM)

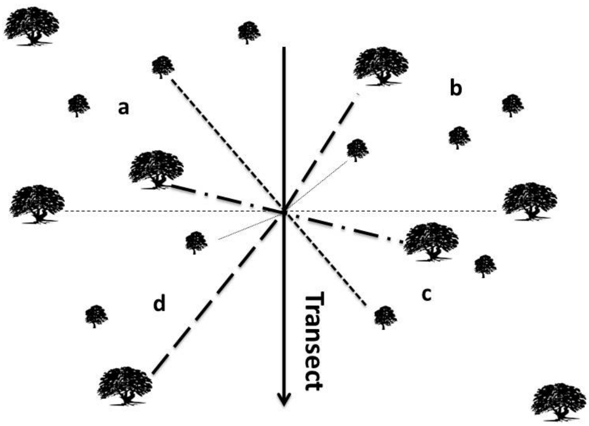


Figure 5. Point-centered quarter method (PCQM) in assessing vegetation showing samples of trees (broken lines) and shrubs (dotted lines) from a single sampling point (Source: Tongway & Hindley, 2004).

WQM is best used on landscapes with sparse vegetation and/or can also be used in advanced stage of natural regeneration of vegetation in the landscape (e.g., when the forests have established).

Position the WQ compass (see the list of LFA tools and equipment in Appendix 1) at the starting point of the transect line. Point the tracking line of the WQM following the transect line. Measure the distance to the nearest plant of the strata being assessed that is within the 90˚ arc centered on the transect line bearing (Fig. 6). Measure the aboveground vegetation parameters of the plant as indicated in Form 4. Then repeat this procedure using the position of the first plant as the new starting point to find the next plant. Continue repeating the procedure until at least 25 plants have been recorded or until the far-end boundary of the block is reached. If there is not enough plant found on the transect line, establish a parallel transect line and continue the procedure until sufficient plants are recorded.

For both methods, record the species' names of the plants. If the species name is not known, give the plant a temporary name, and take a photo for later identification.

The list (and counts) of plant species can be used to assess the diversity of plants in the landscape.

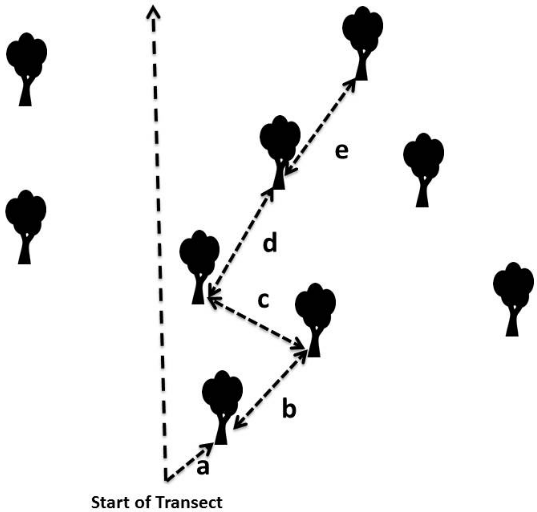


Figure 6. Wandering quarter method (WQM) in assessing vegetation with reference to the LFA transects. (Source: Tongway & Hindley, 2004)

3.7 BEFORE LEAVING THE SITE

- Check that all data are complete, free of mistakes and sensible (based on ocular observation)
- Check if rill assessment is needed, if so, use the Rill Assessment Data Sheet (Appendix 6, page 67)
- Write down observations arising from the data collection (use space provided in the Site Description Form); this will aid discussion in the report
- Check that all data sheets, tools and equipment are packed to go
- Ensure that the transects are permanently marked for easy relocation. Spray the markers with high visibility paint color to facilitate future assessments

3.8 ENTERING DATA AND INFORMATION INTO LFA SPREADSHEETS

It is important to note that every transect line must have its own LFA spreadsheet file. Rename spreadsheet file to include site, transect number and date for easy reference. LFA indices are automatically generated as field data are entered into designated cells in the LFA spreadsheets.

The electronic copy of the LFA spreadsheets are included in the accompanying LFA compact disc or can be downloaded as part of the LFA tool kit from the UPLB website (http://ovcre.uplb.edu.ph/downloads/category/24-landscape-function-analysis).

Start

Enter the information from Form 1 into the Start tab of the spreadsheet.

Summary and Charts

These spreadsheet tabs provide summary reports of the calculated index values and charts AFTER entering all the data collected from each transect into the other spreadsheet tabs. Do not add or change anything in these spreadsheet tabs.

LFA

Enter all the Landscape Organization data (i.e. patch and inter-patch lengths and widths) from Form 2, into the designated cells in this spreadsheet tab.

LFA_work

This is an output or report spreadsheet tab. Do not add or change this spreadsheet tab.

SSA data tabs (indicated as SSA-1, SSA-2, SSA-3 and so on)

Enter all data from Form 3 into the appropriate cells in these spreadsheet tabs. Use one spreadsheet tab for each of the patch and inter-patch query zones as described in the SSA procedure. Do not rename the tabs.

TIP: At the very early stages of landscape restoration, patch and inter-patch patterns are simple enough to need more than 3 of these SSA data entry tabs. If there are more anticipated patch and inter-patch types in a transect line, especially at the early stage of development, lump the closely related patches or inter-patches to improve their groupings.

As complexity increases with the progress of landscape restoration, more SSA data entry tabs would be needed for a single transect. However, advanced landscapes like secondary forests, may have only one patch type for the whole transect (i.e. advanced secondary forest floor patch).

Vegetation data sheets

Data from the vegetation assessment are entered on a separate data sheet (Form 4). An electronic version of the Form is available as a separate spreadsheet file which is included in the LFA tool kit downloadable from the UPLB website (see LFA_vegetation_data_entry.xls).

Use one (1) layer tab for each stratum observed per transect. The spreadsheet has room for a maximum four (4) strata. Strata classification may be based on diameter classes or on height classes but this should be consistent for all sites assessed (i.e. use diameter classes only for all sites) for the results to be comparable.

Biodiversity indices (e.g. Shannon's, Simpson's, Evenness, etc.) may be computed to aid in the analysis (refer to http://www2.ib.unicamp.br/profs/thomas/NE002_2011/maio10/Magurran%202004%20c2-4.pdf) and report writing.

4 Guidelines for Reporting LFA Results

LFA was designed to ensure that written reports for every field assessment activity can be completed and submitted immediately upon return to base or office to guide managers or decision-makers.

LFA reports from every assessment activity and for each assessed landscape or rehabilitation site must include a file of all the LFA Forms, the transect location details and the narrative reports prepared during each assessment period. This will facilitate subsequent assessment activities of the landscape or rehabilitation project site.

4.1 THE INTRODUCTION OF THE REPORT

The introduction must provide a brief background history of the landscape being assessed. Include brief overview of the original characteristics of the landscape prior to disturbance, the nature and severity of the disturbance, the objective of rehabilitation efforts, the rehabilitation management approach being applied, and other relevant information (e.g., land ownership, size of the land, geology, climate, etc) including any agreement among stakeholders. Then, present the aim and intention (objectives) of the LFA assessment conducted on the rehabilitation project site.

Tip: Introduction and methods part of the LFA report should already be done prior to conducting the assessment. The background information to be written in the introduction part, as mentioned in the earlier sections of this guide, should have been gathered even before planning and conducting the assessment. The methods part should only be brief since this can be referred to the LFA procedures discussed in this guide.

4.2 REPORTING THE METHOD

Describe briefly the overall method used in the assessment and how LFA methodology was applied.

In addition, give a concise discussion on how the number and transect lay out were determined for the size and configuration of the landscapes being assessed.

4.3 SITE DESCRIPTION REPORT

The information collected using the LFA Site Description data sheet (Form 1) will serve as basis of this section. Secondary data can also be used to describe the site's biophysical conditions. The section should consist of:

a. Overview about the landscape conditions in surrounding areas;
b. Climatic conditions of the area (i.e., rainfall or temperature); and
c. The nature of the disturbance, man-made or natural, on the geo-biological characteristics of the landscape being assessed;
d. Map(s) showing the rehabilitation sites and transects.

4.4 LANDSCAPE ORGANIZATION REPORT

This section presents the data collected and generated information about the organization of the assessed landscape (Form 2).

Discuss results of the assessment and other recorded observations while on site.

The Landscape Organization Index (LOI) describes the ratio of patch to inter-patch in the landscape being assessed.

The landscape organization index is an important part of this section. The index describes the ratio of patch to inter-patch in the area being assessed. The LOI can be used as a parameter for comparing landscapes. A lower LOI means the presence of more inter-patches or gaps within landscape which indicate tendency towards dysfunctional state of the landscape. For example, a rehabilitation site which has an LOI of 0.10 is in a poor or dysfunctional state than a landscape with LOI of 0.98 (which means more patches than inter-patches). Knowing the LOI of a given landscape signals managers to action by assessing and adjusting the geotechnical aspect of the landscape, by laying semi-permanent topsoil cover, by fixing the topsoil properties, by improving patch type and quantity, and/or by rapid establishment of vegetation cover (i.e., by direct-seeding and/or planting).

Comparing the LOI change of one landscape though time will determine the trend or trajectory by which the landscape is progressing through the landscape development curve (which follows an upward Sigmoid or S curve). Obviously, a downward trend indicates the landscape is heading to a further dysfunctional landscape organization which managers have to be addressed immediately.

4.5 SOIL SURFACE ASSESSMENT REPORT

Report the three indices (namely Stability Index, Infiltration Index and Nutrient Cycling Index) resulting from the Soil Surface Assessment (Form 3) of the transect lines.

The indices for Stability, Infiltration and Nutrient Cycling will have values to maximum of 100 as computed in the LFA spreadsheet. Higher values will mean higher functionality for the respective indices. The computed values of the three indices can be found in the Summary spreadsheet tab. The three indices can be used to compare landscape status at different sites by simply combining them in a table or a graph, for an example see Figure 7.

Index	2 year-old Rehab Area	SE	6 year-old Rehab Area	SE	Analogue	SE
Stability	67.8	2.2	71.7	1.6	93.8	0.0
Infiltration	41.1	2.5	53.7	1.0	78.6	0.8
Nutrient Cycling	35.4	1.3	43.4	1.4	77.4	1.1

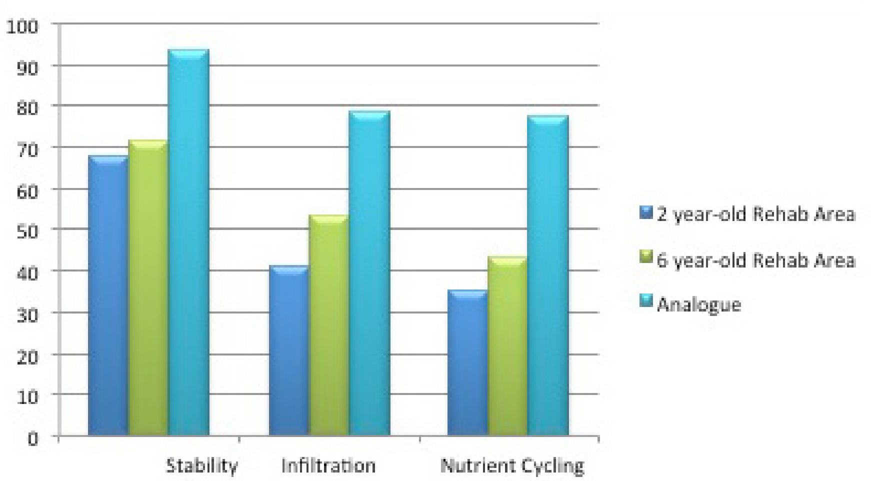


Figure 7. Sample graph made using the different indices from three transects (data taken from Rio Tuba Nickel Mining Corporation, Palawan).

The LFA spreadsheet will also compute for standard errors in the scoring of the SSA indicators. The standard error is used to check the statistical acceptability of the data and results. It is important to have a standard error less than 2.5. Such standard error can be adjusted (lowered) by adding more replications within the transect line (i.e., by increasing the length of the transect line in order to add repeats or replication of the patch and inter-patch patterns).

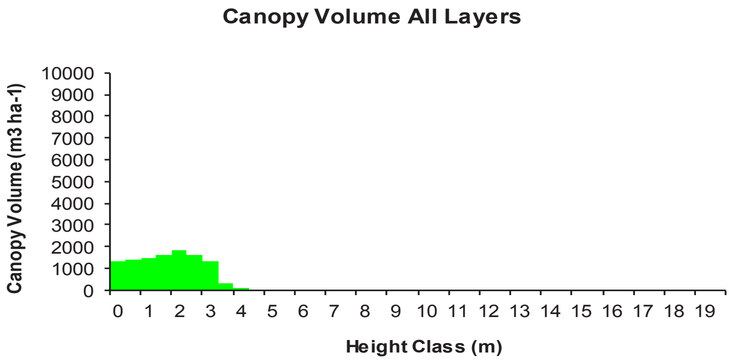
If the assessment is being conducted as a sequel to a previous assessment, present the results of the current as a comparison of the results of the previous assessment. This will show the trend and quality of change in the patches and inter-patches.

4.6 VEGETATION ASSESSMENT REPORT

Vegetation assessment will provide the following information:

- Density of plants per unit area of each vegetation strata (or life form)
- For grass strata, basal area (sq m) per unit area
- For shrubs and trees, canopy area (an index of habitat quality) canopy volume (an index of growth) horizontal cross sectional area in height classes (an index for wind amelioration)

See interpretation of vegetation assessment results (Figure 8), Manual on Landscape Function Analysis (Tongway and Hindley, 2004, pages 69-71) as cited in the References of this Guidebook.



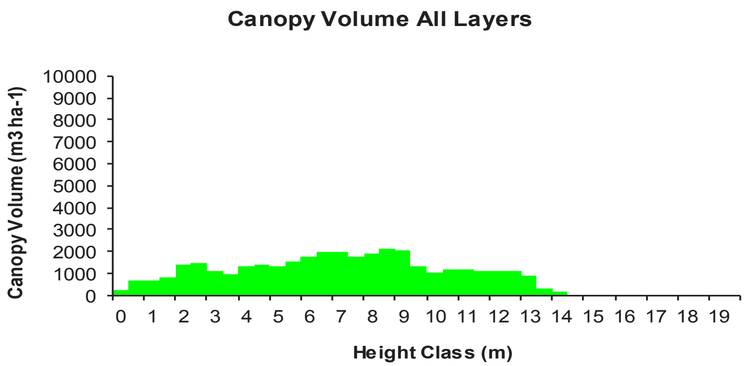


Figure 8. Example of graphs generated through the LFA vegetation data entry spreadsheet of two different sites: a 2-year-old rehabilitation (top) and a 6-year-old rehabilitation area (bottom) in Rio Tuba Nickel Mining Corporation, Rio Tuba, Bataraza, Palawan.

4.7 DRAWING CONCLUSIONS FROM THE LFA ASSESSMENT RESULTS

Comparing landscape status across different sites

LFA indices across different landscapes or sites can be used to compare two or more landscapes or rehabilitation sites; for example, in comparing landscape function of a rehabilitation site versus an analogue or reference site (see Figure 9).

Comparing landscape status of a site through time

Monitoring LFA indices through time, preferably at the same season or time of the calendar year, can be plotted in a graph to check rehabilitation progress (see Figure 9). Continuous monitoring of LFA indices of a landscape being rehabilitated is expected to follow a sigmoid or S curve. An upward trend indicates positive progress towards higher functionality, while a downward trend indicates a negative progress towards further dysfunction which may require additional intervention.

Assessing self-sustainability of landscapes

A highly functional and self-sustaining landscape is the goal of landscape rehabilitation. Plotting LFA indices through time can be used to estimate the point of inflection in the S curve (see Figure 10), at which the landscape function will progress on at a self-sustaining rate to higher complexity or functional state. By having an idea of the inflection point, land managers can have an estimate of how much time and resources will be needed to reach a self-sustaining status. This is vital to mine and land rehabilitation planning which LFA can provide.

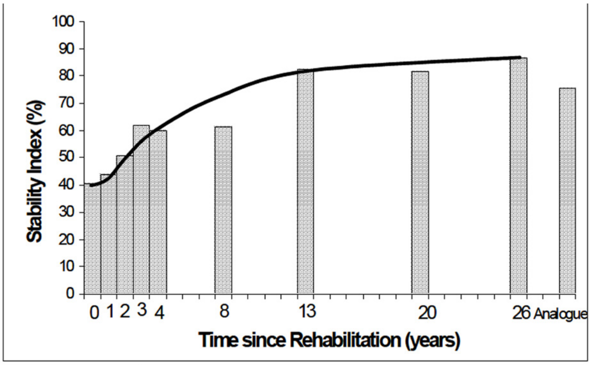


Figure 9. Sample time series stability index trend for a rehabilitation site compared to an analogue site at Alcan Gove Bauxite Mine, Northern Australia. Lower value of the analogue than the 26-year-old rehabilitation site is attributed to frequent burning of the former (Source: Tongway & Hindley, 2004).

4.8 APPENDING LFA DATASHEETS TO REPORTS FOR REFERENCE

Copies of all the completed Forms (data sheets) and photos of the transect line taken during the field assessment must be attached to the LFA report as appendices.

The Sigmoidal Curve of Landscape Function Development

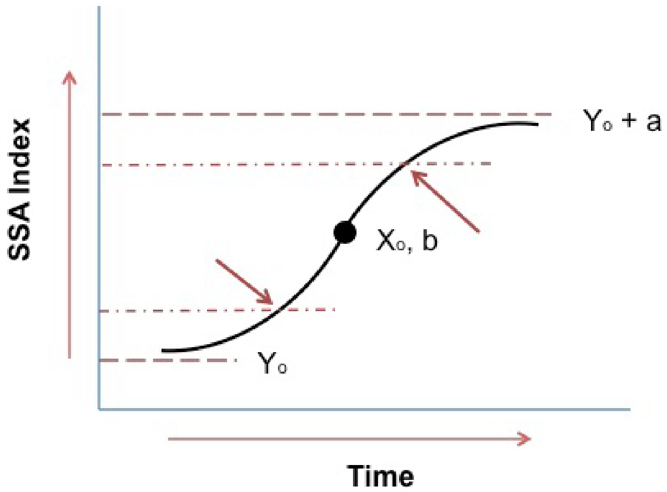


Figure 10. A Sigmoidal curve representing the predicted progress of landscape functions in an area (Tongway & Hindley, 2004).

Plotting LFA indices of a developing landscape over time follows a Sigmoidal or S-curve (see Figure 10). The curve is defined by an upper limit Y_o+ a and lower limit Y_o. A site's landscape function can be assessed and located along this range or curve. The first point which a rehabilitation effort must aim to reach is the midpoint or inflection point (X_0, b); while the upper limit Y_o+ a is the long-term goal. The lower limit Y_o represents the lowest landscape functionality; any values lower than Y_o would mean total collapse of the landscape. Knowing the status of landscape functionality of a given site being rehabilitated will aid in determining the amount of management interventions to reach the objective of the rehabilitation project.

Every landscape will have a site specific S-curve. Determining an upper and lower limit before starting rehabilitation effort facilitates the setting of objectives and in planning rehabilitation plan or strategy.

An agreed analogue or reference site which has the highest LFA indices can be used as the upper limit Y_o+ a; while the site that needs rehabilitation and which would have the lowest LFA indices can be used as the lower limit Y_o. The midpoint or inflection point of the S-curve X_0, b can be determined as the average of the upper and lower limits.

By plotting the LFA indices through time of a given landscape, it will show whether the landscape is progressing upwards to the upper limit, or worse if the trend is progressing downward below the lower limit. Once the landscape functionality reaches past the midpoint and nearing the upper limit, progress is anticipated to slow down even with additional rehabilitation efforts. Careful observations must be conducted to check if the landscape can self-sustain the level of functionality. If the functionality is sustained after years of monitoring, this indicates that the area is sustainably functioning and may no longer need continuing intervention.

5 Reference

Tongway D J & Hindley N L. 2004. Landscape Function Analysis: Procedures for monitoring and assessing landscapes. CSIRO Ecosystems Sciences, Black Mountain Laboratories, Canberra ACT Australia.

Glossary

The terms and definitions in this section specifically serve for the purpose of this handbook.

Functionality	The ecological functions done and maintained by a landscape/site to sustain itself
Index/Indices	LFA values calculated in the LFA spreadsheets which represent the three major ecological functions in a landscape: stability, infiltration and nutrient cycling
Indicator	A criteria scored in the field which determines the function of a portion of a landscape
Infiltration	The capability and the rate of the ground to absorb water
Inter-patch	Portion of the landscape which is likely to lose resources or let it pass through
Monitoring	An activity which aims to assess a landscape/area periodically or by conducting a series of measurements
Nutrient Cycling	The function of a landscape which entails the recycling of organic matter (plant or animal) into readily available forms to be used by plants
Perennial plants	Species of plants which persist for over a year
Perpendicular	Forming a 90-degree angle
Patch	Portion of the landscape which is likely to hold/trap precious resources specially in the event of surface run-off
Patch width	Longest portion of a patch perpendicular to the transect
Sustainability	"The state of providing resources and other benefits in perpetuity without threatening future supplies", published in a book by Burley, Evans, & Youngquist in 2004 (Encyclopedia of Forest Sciences)
Transect	The established line on the ground subjected to LFA

Appendices

Appendix 1

LFA Tools and Equipment

- 1 unit GPS for determining coordinates of the start and end of transect
- 1 unit Compass for determining transect line orientation
- 1 unit Survey tape (50 or 100 meters)
- 2 units steel pegs to hold the start and end of the survey tape in place
- 1 unit Retractable measuring tape (10 meters)
- 50 units marker pins (2 colors)
- Sets of field data sheets (printed or on computer tablets, see samples of field data sheets below)
- 1 Liter bottle of rain water or de-ionized water for slake test
- 1 unit 100 mm diameter dish for slake test
- 1 unit 1mm aperture brass sieve (100 mm diameter frame) for preparing soil for texture test
- 1 unit camera (for photo documentation)

WQM-PCQM VEGETATION ASSESSMENT TOOLS

- 1 unit Compass mounted on a 30cm x 30cm board

Appendix 2

Form 1: LFA Site Description

Site No. . . . . Date . . . .

Site Name . . . . Observer . . . .

Position (GPS) . . . .

Transect Compass Bearing . . . .

Position in Landscape . . . .

Lithology . . . .

Soils . . . .

Slope . . . . Aspect . . . .

Vegetation Type . . . .

Land Use . . . .

State of Soil Surface . . . .

Comments

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Appendix 3

Form 2: LFA Landscape Organization

Date . . . . Observer . . . .

Site Name . . . . Transect . . . .

Distance (m)	Patch width (m)	Patch/Interpatch Identity	Notes
0			

Appendix 4

Form 3: LFA Soil Surface Assessment (SSA)

Date:.. Observer:…………………....................

Transect..

Site Name...

Each query point needs to have it's **transect location** (in metres from 0) and its landscape **patch and interpatch type** identified.

Surface Features	**Class Values of Surface Features**														
Patch/interpatch Ident. / **SSA Indicator**															
Rainsplash Protection (1-5)															
Perennial vegetation cover (1-4)															
Litter cover, origin & incorporation (1-10)															
Biological Soil Crust cover 0, 1-4															
Physical Crust broken-ness 0, 1-4															
Erosion type & Severity (1-4)															
Deposited materials (1-4)															
Soil Surface Roughness (1-5)															
Surface dry coherence (1-5)															
Slake test (soil wet coherence (1-4)															
Texture (1-4)															

Appendix 5

Form 4: LFA Vegetation Assessment - Wandering Quarter Method and Point Centered Quarter Method

EFA Point-centred Quarter and/or Wandering Quarter Data Sheet

Site Name ………………………….. Transect ……………………………………………………….

Date ……/……/………. Observer ……………………………

No	Quart	Species	Dist. (m)	Canopy width (m)	Canopy breadth (m)	Tot Height (m)	Height to canopy (m)	Canopy density (%)
1	1a							
2	1b							
3	1c							
4	1d							
5	2a							
6	2b							
7	3c							
8	3d							
9	3a							
10	3b							
11	3c							
12	3d							
13	4a							
14	4b							
15	4c							
16	4d							
17	5a							
18	5b							
19	5c							
20	5d							
21	6a							
22	6b							
23	6c							
24	6d							
25	7a							
26	7b							
27	7c							
28	7d							
29	8a							
30	8b							
31	8c							
32	8d							
33	9a							
34	9b							
35	9c							
36	9d							
37	10a							
38	10b							
39	10c							
40	10d							
41	11a							
42	11b							
43	11c							
44	11d							
45	12a							
46	12b							
47	12c							
48	12d							

No. Ident.	Quart Ident.	Species Ident	Dist. (m)	Canopy width (m)	Canopy breadth (m)	Tot Height (m)	Height to canopy (m)	Canopy density (%)
49	13a							
50	13b							
51	13c							
52	13d							
53	14a							
54	14b							
55	14c							
56	14d							
57	15a							
58	15b							
59	15c							
60	15d							
61	16a							
62	16b							
63	16c							
64	16d							
65	17a							
66	17b							
67	17c							
68	17d							
69	18a							
70	18b							
71	18c							
72	18d							
73	19a							
74	19b							
75	19c							
76	19d							
77	20a							
78	20b							
79	20c							
80	20d							
81	21a							
82	21b							
83	21c							
84	21d							
85	22a							
86	22b							
87	22c							
88	22d							
89	23a							
90	23b							
91	23c							
92	23d							
93	24a							
94	24b							
95	24c							
96	24d							
97	25a							
98	25b							
99	25c							
100	25d							

Appendix 6

Form 5: Rill Assessment

Site .... Transcect ....

Date .... Observer ....

Transect	L/O Transect Distance (m)	Start of Rill Edge (m)	Finish of Rill Edge (m)	Rill Depth (m)	Rill Bed Nature	Comment