Landscape Organisation Assessment (LOA):
LFA Procedures for Assessing How a Landscape is Organised

In chapter 13 of our book on "Restoring Disturbed Landscapes: Putting Principles into Practice" (Island Press, 2011), we provide an overview on landscape function analysis (LFA). Essentially, LFA is a set of assessment procedures for monitoring indicators of how well landscapes are functioning in terms of the state of functionality of their biophysical processes. Indicators of these processes are monitored at two landscape scales: the site scale (e.g., a hillslope), and the patch scale (e.g., vegetation patches/bare soil inter-patches).

Aim:

In this document we describe procedures for assessing attributes on how a landscape is organised (patterned) at the site scale. The attributes measured at this scale aim to indicate how well biophysical processes involved in retaining vital resources are operating within the overall landscape. For example, is water from rainfall being retained because the landscape is uniformly covered with a high density of vegetation patches having high infiltration rates – do these patches also obstruct and slow any flows of runoff to provide more time for infiltration?

Procedures:

At the site scale, LOA procedures are applied to sites located within restored landscapes and also to sites located within undisturbed reference areas, ideally nearby in similar landscapes. The LOA procedures described here also apply to sites within restored landscapes that involve reconstructed landsforms such as rehabilitated waste rock dumps and tailings storage facilities on mines.

1. Site selection

The first task is selecting sites within a restored landscape that are typical of the overall state of restoration. In cases where the state of progress of restoration is slow in some areas of the restored landscape and faster in others, and time and personnel are not limiting, then it is useful to select sites capturing this variation, which is likely to help understand why these differences occur.

Part of this task is to also select sites within nearby undisturbed landscapes. These sites are where biophysical processes are operating in as natural a manner as possible. In many areas it is difficult to find undisturbed landscapes. In this case, it is necessary to select a relatively undisturbed site, that is, where the history of disturbances and their effect on the landscape are known. If this is not possible, it may be necessary to define (hypothetically) an undisturbed landscape based on expert knowledge on how natural landscapes are likely to function within the area.

2. Site sampling

Next, selected sites are sampled by one or more line transects oriented along a gradient such as down a slope (Figure 1), or in the direction of prevailing winds. These transects can be called gradsects, a contraction of "gradient-oriented transect". We have typically used three gradsects to characterize how a landscape is organised, with gradsects laterally separated by 25 to 50 m. Gradsects are typically straight, but transects can be curved or bent to more closely follow, for example, the pattern of runoff water. Gradsect length may vary depending on your purpose, the setting (e.g., size of the restoration area) and the scale of landscape pattern. Gradsects of 50 m may adequately sample restored landscapes with a fine-scale, regular pattern, such as sites selected on constructed landforms on mines (see Addendum). However, gradsects of 100 m or more may be required to adequately sample restored sites with coarse-scale, irregular patterns, such as often found on arid and semiarid rangelands.

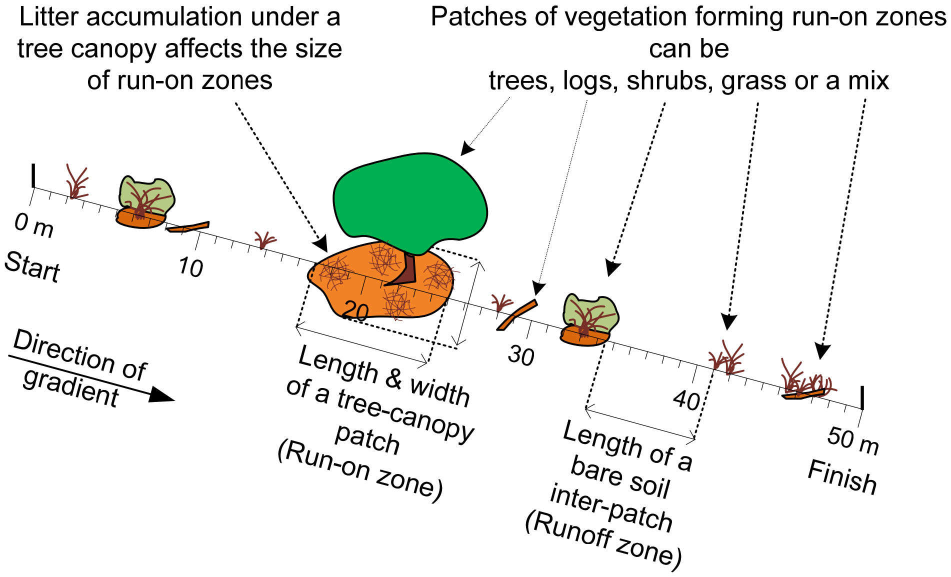

Figure 1. A schematic illustration of a 50-meter gradsect where distances along the transect are measured to record the location of resource accumulating patches (run-on zones), such as grass clumps, shrubs and trees, and resource shedding inter-patches (runoff zones), such as bare soil.

3. Gradsect measurements

Third, to characterise how the site (landscape) is spatially organized or patterned, measurements are made, for example, along gradsects from upslope to downslope to follow sequences of runoff and runon patches (Figure 1). The upslope end of the gradsect (start) is positioned at a boundary between a patch (e.g., a grass tussock) and an inter-patch (e.g., bare soil), specifically where the inter-patch begins. As described in the Addendum, measuring patches and inter-patches along gradsects positioned within constructed landforms requires a number of additional considerations to assess how these landscapes are spatially patterned. For example, to assess how resources are being regulated, patches and inter-patches formed by "bank and trough" systems created by ripping along contours need to be measured.

The measurement recorded at this starting position is "0", as shown in the left-hand "Distance" column of Table 1, an "Example: Landscape Organisation Data Form". The first recorded distance (2.32 m) defines the downslope dimension of a bare soil inter-patch. On the third column from the left in the Data Form, a code is written, which is an abbreviation of the nature of the inter-patch (e.g., bs = bare soil). The right-hand column can be used to write notes about patches and inter-patches.

Table 1. Example: LFA Landscape Organisation Data Form

Date: day/month/year Observer(s): Jane & John Smith

Site Name: LFA Magic Land Transect Number: 1 Page 1

Distance (m)	**Patch Width (cm)**	**Patch/Interpatch Identity**	**Notes**
0			
2.32		**bs**	**bs = bare soil**
3.44	**75**	**gt**	**gt = grass tussock (tufted, not**
4.91		**bs**	**stoloniferous or a hummock)**
5.45	**102**	**gt**	
6.71		**bs**	
7.12	**87**	**gt**	
8.43		**bs**	
8.90	**37**	**gt**	
10.11		**bs**	
11.25	**123**	**gt**	
etc.	etc.	etc.	

Site Name: ________________________ Transect Number: ____________

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Distance (m)	**Patch Width (cm)**	**Patch/Interpatch Identity**	**Notes**
etc.	etc.	etc.	
100.0		**bs**	**Transect ends on bare soil**

Note that Table 1 is an abbreviated example of data recorded along a 100-m gradsect in a grassland composed of fine-scale grass patches separated by inter-patches of bare soil. The vegetation patches are small groups of grass tussocks and the bare soil inter-patches have physical crusts. A complete example of records along a 50-m gradsect is provided by Table 13.2 in our “Restoring Disturbed Landscapes” book.

The third line of data on the Data Form (Table 1) records the distance along the gradsect where the grass tussock patch ends (3.44 m), that is, where the next boundary between bare soil and a grass tussock (gt, a “patch”) is located. The lateral extent of the patch (75 cm or 0.75 m) is also recorded in the second left column. No inter-patch width is conventionally measured. This data recording procedure of distances, codes and notes is used to the end of the gradsect, or for completeness at the end of a patch/inter-patch boundary, which may be just beyond the end of the transect measuring tape.

The identity and naming of patches and inter-patches is up to the observer. As a routine, a photograph of each patch type is taken. Also note in Table 1 that only a single column of distance numbers is recorded with this system for recording defined patch and inter-patch boundaries. This saves time in the field.

4. Indicators of landscape functionality

Gradsect data can summarised to provide information on indicators about how the landscape is organised. Although these indicator data can summarised by using a hand calculator, it is more efficient to key-in these data into a spreadsheet (SSA-DataSum.xls), which is provided in the LFA web page. This spreadsheet calculates, for example, the mean number of vegetation patches found per 10 m of gradsect (Table 2). These landscape function indicator data are also shown as Table 13.3 in “Restoring Disturbed Landscapes”. Note that the number of vegetation patches (2.4) per 10 m represents a linear density of patches – a high density indicates a high capacity of the landscape to retain resources, whereas a low density would indicate a lesser capacity. The total width of vegetation patch (4.1 m) per 10 m also indicates the capacity of the landscape to retain resources, whereas the mean length of inter-patches (bare soil) indicates the potential for the landscape to lose resources.

Table 2. Example: Indicators of landscape organization

No. patch zones per 10 m	Total patch zone Width (m/10 m)	Mean interpatch length and *range* (m)	Landscape organization Index
2.4	4.1	3.2 (*0. 6 to 9.8)*	0.22

A landscape organisation index (LOI) is also calculated, which is the sum of all individual patch lengths measured along the gradsect divided by the total length of the gradsect. LOI can vary from 0.0 (a totally bare site) to 1.0 (a site totally covered by vegetation).

Addendum

Assessing patches and inter-patches on constructed landforms

Typically on mines, waste rock dumps and tailing storage facilities are reshaped into new landforms and then these rehabilitated landscapes are deep-ripped along contours to produce “bank and trough” structures (Figure 2). These created structures forms the primary means of resource regulation from the earliest stages of landscape rehabilitation, and often lasting many years. If the ripping is not carefully aligned with the contour, lateral water flow along the trough may well ensue, with ultimately a major failure of the ripping as very large volumes of water move quickly to the lowest point in the trough and break through the banks.

Figure 2. On a mine, a constructed slope has been contour ripped to produce a “bank and trough” system aimed to regulate resources. There are no signs of lateral flow in the troughs and hence no rills or gullies have formed on this slope.

In this “bank and trough” system the trough is the patch (traps resources) and the bank the inter-patch (sheds resources) (Figure 3). The patch width (trough) is measured by assessing the intactness of the downslope bank to a maximum of 5 metres on either side (10 m total) or to an erosion rill through the bank where resources are being lost downslope. Typically on newly ripped surfaces, all banks will be intact and 10 m long. An important task of monitoring ripped landscapes is to observe if and when rills cut through the bank. This would trigger a Rill Assessment exercise.

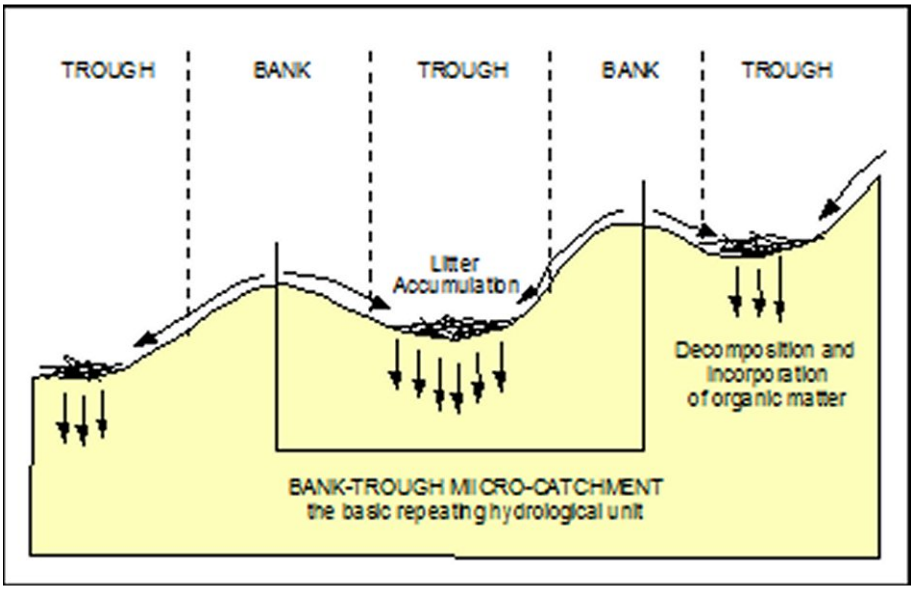

Figure 3. A cross-sectional representation of contour ripping on a sloped landscape showing the fine-scale resource regulation created by a bank and trough system.

Using the LOA field data form (Table 1), the transect landscape organisation records the successive bare bank (inter-patch) and bare trough (patch) widths. Measuring and recording these patch and inter-patch widths requires locating the boundaries of the banks and troughs (Figure 4). These boundaries and subsequent measurements are based on the concept of the hillslope gradient (slope) prior to ripping, to act as a guide for landscape organisation assessment. The trough peaks would be below the hillslope gradient and the bank crest above it. A rapid and consistent assessment is more important than slow precision. The diagram illustrated by Figure 4 also shows the “surface roughness” dimension needed in the SSA classification process (see the SSA-Proc document for details on this LFA indicator).

Initially, bare banks and troughs are all that is recorded, but over time, as plants colonise, troughs may become “grassy troughs” or “shrubby troughs” to reflect this ecological advance. Woody debris may have been spread on the slope and its resource regulation capacity would be added to the basic ripping treatment. It is important to observe that the correct distance that the debris is in contact with the ground and that sediment is building on the upslope side of the debris.

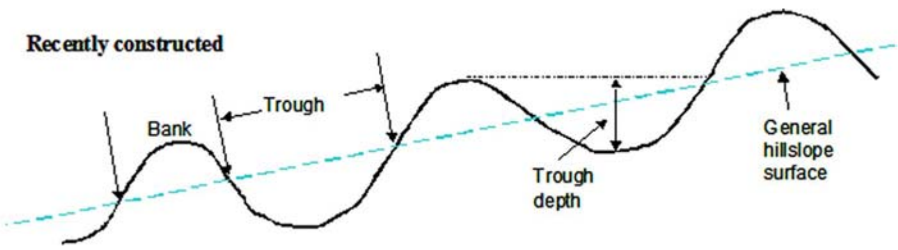

Figure 4. A diagrammatic representation of a bank/trough slope showing the measurements of patch (trough) and inter-patch (bank) widths, and the trough depth assessed in the surface roughness indicator in the SSA data set. Typically, this indicator will initially be class 4 (>100 mm retentive relief).

As time proceeds, the troughs will receive and store sediment from the adjacent banks. This would be recorded in the "deposited material" in the SSA assessment. If erosion rates are excessive, the trough may fill with sediment and become a "flat". If this stage is reached, the former trough ceases to be a patch and becomes an inter-patch. This would constitute a major decline in landscape functioning and would be reported as needing intervention to repair.