Vegetation Structure Assessment (VSA):

LFA Procedures for Measuring Vegetation Structure and its Functional Role

Vegetation plays an important functional role in providing ‘goods and services’ for both itself (i.e., self-sustaining ecosystems) and for other biota (i.e., suitable habitat, food and shelter), including humans. Typically, vegetation monitoring looks in detail at plant species composition and biomass, with less emphasis on its structure and functional role in the landscape. Although species composition is of some importance, it reflects the history of the ecosystem and largely lacks predictive capacity. That is, if species “X” is missing from rehabilitation site, there is no intrinsic information in the vegetation composition data that can assist in deciding why this is so, or what to do about it. Individual observers may use their experience and intuition to make practical suggestions, but these mental syntheses are extrinsic to the data. We argue that monitoring vegetation structure and its function in the landscape is of greater importance.

Methods of assessing vegetation structure and function are well developed and time-honored procedures have been books without substantive modification for decades (e.g., Canfield, 1941; Shimwell, 1971;Mueller-Dombois and Ellenberg, 1974; Bonham 1989). From these books, we describe in chapter 16 of our book on “Restoring Disturbed Landscapes: Putting Principles into Practice” (Island Press, 2011) methods for measuring vegetation structure and for assessing landscape functions.

Aim:

In this document we summarize from our chapter 16 those methods for measuring vegetation structure and assessing function that we have found to be useful for restoration practitioners (RPs), especially those RPs using landscape function analysis (LFA) procedures to monitor rehabilitated landscapes. The indices developed from these vegetation measurements reflect both the traditional factors of structure and to a lesser extent, composition, but importantly add the functional role of vegetation in regulating vital resources whether wind or water is the mobilizing agent. This is in accordance with the conceptual framework described in our chapter 2 in “Restoring Disturbed Landscapes”.

Procedures:

The following methods for measuring vegetation data are presented graphically so that a "picture" of vegetation function emerges.

1. Site selection and sampling

The first task is to select a site within a landscape being rehabilitated, or within an undisturbed reference area, and then establish one or more transects within this site to sample the vegetation. As described in our web page document on assessing how a landscape is organized (LOA-Proc.pdf), these transects are oriented along environmental gradients, such as down a slope or in the direction of prevailing winds. By orienting transects along gradients, the function role of vegetation structure can be assessed as a "cause and effect" set of sequences, indicating how well patches of vegetation are functioning to retain water during and after rainfall events. Vegetation measurements are collected along the same transects.

2. Transect methods

Here we describe two methods for measuring distances to plants from points established along transects. These measurement procedures are known as "plot-less, distance" methods, which are conventional to vegetation science (see Bonham, 1989). The point-to-plant distance data are traditionally used to estimate vegetation density. But, density is only one attribute of vegetation structure and indicator of its functional role. We recommend that RPs collect additional data on each plant identified when measuring point-to-plant distances; these additional data are described in the next section, "3 Plant measures".

The two plot-less distance methods are:

Point Centred Quarter (PCQ)

First, at regular intervals along the LFA transect line, sampling points are established. The interval length based on the density of plants. For example, very dense grassy swards might make the interval 1-m, but sparser grassy tussock vegetation might need 3-m, or more.

Second, at each sample point, the distance to the nearest plant of interest in each of the 4 quarters (sectors) around the point is measured (Figure 1). [As noted above, additional data will be collected on each plant (see the section 3).] As a guide, a minimum of 20 points, with 4 plants measured per point will provide an adequate sample of distances. A rule applies: if distances from two adjacent points along a transect are measured to the **same** plant, this will introduce a bias to the density estimate. This means that the interval length between points along the transect is too short, and a longer interval length should be used. Also, because of the regular spacing of trees, we do not recommend using the PCQ method in plantations.

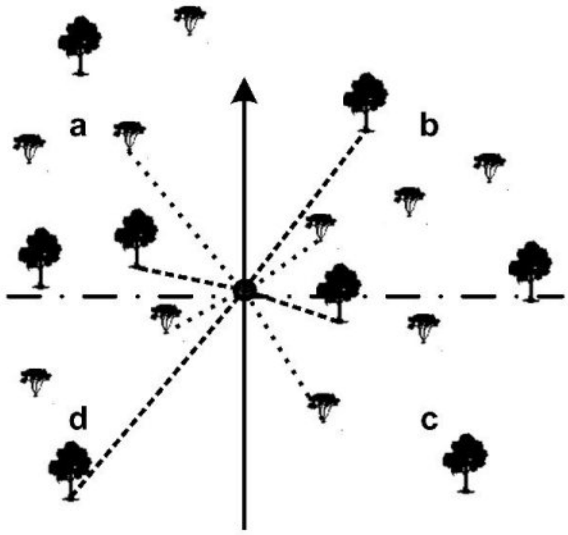

Figure 1. The point-centred quarter (PCQ) method of measuring distances from a point along a transect to vegetation in each of four quarters (a, b, c, d). Distances to **the nearest tree** in each quarter are shown as dashed lines, and distances **to the nearest shrub** by dotted lines. Although not illustrated, distances to the nearest grass plant in each quarter could also be measured.

The distance data can be conveniently recorded in the field on the printable field data form, VSA-DataForm.pdf, which is available on the LFA web page. Field data can also be keyed into the available spreadsheet, VSA-DataSum.xls, which checks that the correct distance dimensions are recorded. Instructions for keying in PCQ data and for interpreting output from the spreadsheet are given in the LFA web page document VSA-DataSum-Proc.pdf.

Wandering Quarter (WQ)

This is another plot-less distance method, which is similar to PCQ but is more practical in sparse vegetation, such as where trees and shrubs as widely spaced.

First, from the start of the transect at 0 m, and using its compass bearing, measure the distance to base of the nearest plant located within a 90 degree arc in the direction of the compass bearing (Figure 2). [As noted earlier, additional data will be collected on each of these plants as described in the next section (3).].

Second, move to that plant and establish a new 90 degree arc with the compass bearing and measure the distance to the next nearest plant (Figure 2).

Third, repeat this process until the full transect length is covered. We recommend that a minimum of 25 plants be assessed to produce unbiased estimates.

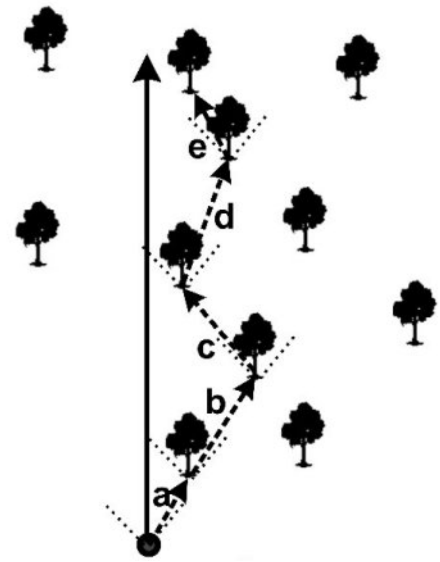

Figure 2. The Wandering-Quarter (WQ) method of measuring distances between plants (dashed arrows) located within a 90 degree arc (dotted lines). Distances between trees are illustrated here, but distances between shrubs, or between grass tussocks, could also be measured using this WQ method.

Although the WQ process deviates off the transect, it is important to sample over the landscape area covered by the transect (e.g., from 0 to 100 m). However, if covering the full transect length would produce an excess of distance data (e.g., > 100 distances), then the WQ process could finish before the full length is covered, or sampling could be stratified along the transect, for example, by using starting points at zero until 50 distances are samples, and then using another starting point at 50 m along the transect to sample another 50 distances. If less than 25 distances between plants are recorded when the full length of the transect area has been covered, then we recommend establishing additional transect lines parallel to the first transect to obtain more distance data. However, **do not treat these lines as statistical replicates**; they only sample the same landscape area.

3. Plant measures

To assess functional roles of vegetation, such as how the plants affect resource regulating processes, we recommend measuring additional attributes on the plants identified when making distance measurements. These additional plant structure data should include:

- Overall height,
- Height to canopy,
- Width and breadth of canopy and
- Canopy density (% of overall canopy space occupied by foliage and stems)

For trees, these measures are illustrated in Figure 3. Similar plant dimension measurements would be made for shrubs.

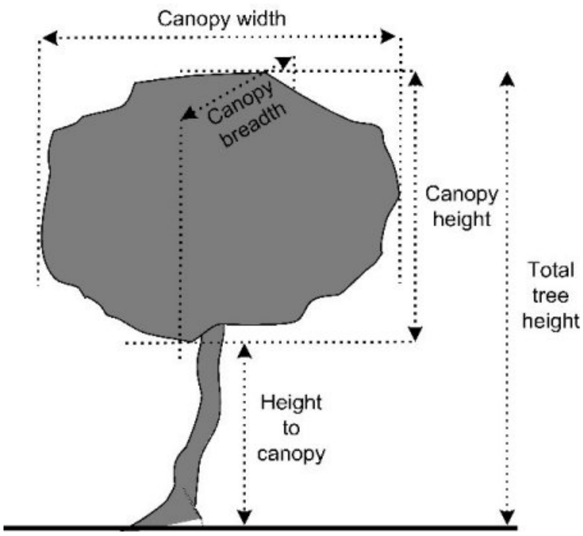

Figure 3. Tree structure dimensions useful for assessing vegetation functions.

For tussock and hummock grasses, plant measurements would be:

- Width and breadth of the butt of grasses,
- Height to canopy is zero, by definition and total height (care needs to be taken with grass data if they are subject to grazing).

4. Vegetation structure indices

After keying in the distance data from the PCQ and WQ method and the plant dimension data described above, the spreadsheet, VSA-DataSum.xls, calculates the following vegetation indices:

a) Plant density (number of plants per hectare) for each plant life form measured (e.g., tree, shrub, grass)

b) For trees and shrubs, canopy area and canopy volume (m^3 per hectare), and for grasses, total basal area (m^2 per hectare).

c) The horizontal cross sectional area in height classes: an index for wind amelioration along the landscape surface (see Figure 4 in the next section).

For example, the following abbreviated data set in Table 1 was collected for shrubs using the PCQ method, and the spreadsheet calculated the vegetation attributes shown in Table 2.

Table 1. Example distance and shrub dimension data collected using the PCQ method.

Transect Dist	Quarter	Distance (m)	Species	Hgt (m)	Width (m)	Breadth (m)	Vol. (m^3)
0	a	0.7	Atsp	0.25	0.3	0.25	0.019
	b	1.6	Atsp	0.35	0.25	0.3	0.026
	c	3.5	Acsp	0.2	0.1	0.1	0.002
	d	2	Ddsp	0.8	1	0.9	0.720
10	a	1.1	Ddsp	0.6	0.9	1.1	0.594
	b	0.8	Acsp	0.1	0.12	0.12	0.001
	c	1.9	Acsp	0.2	0.1	0.1	0.002
	d	1.8	Atsp	0.4	0.4	0.3	0.048
20	a	1.3	Ddsp	0.7	0.3	0.4	0.084
	b	0.7	Atsp	0.15	0.1	0.1	0.002
	c	1.5	Acsp	0.2	0.1	0.1	0.002
	d	2	Atsp	0.35	0.25	0.2	0.018
30	a	3.1	Ddsp	0.85	0.9	0.8	0.612
	b	1.7	Atsp	0.25	0.2	0.15	0.008
	c	1.1	Acsp	0.15	0.1	0.1	0.002
	d	1.9	Ddsp	0.75	0.8	0.7	0.420
40	a	2.5	Ddsp	0.65	0.55	0.6	0.215
	b	2.2	Acsp	0.15	0.1	0.1	0.002
	c	1.4	Atsp	0.3	0.2	0.2	0.012
	d	2.8	Ddsp	0.9	1	1.1	0.990
Total	**20 points**	**35.6**		**8.3**	**7.77**	**7.72**	**3.776**

Table 2. Vegetation structure indices calculated from the data in Table 1.

Mean Distance (MD) between shrubs = 35.6/20 =1.78 m

Density (D) or number of shrubs per 100 m^2 = $100/(1.78)^2$ = 100/3.17 = 31.5 per 100 m^2 or 3156 shrubs per ha (10,000 m^2)

Canopy Volume (CV) = 3.8 m^3 per hectare

5. Interpretation of the functional role of vegetation structure

How vegetation functions to regulate the flows of wind and water through a landscape can be illustrated by graphing summaries of the vegetative cover in m^2 per ha resolved into 0.5 m height slices for two woodland sites, which are the same woodland type but of different health or condition states (Figure 4). The data graphed were summarised from the data collected in four layers: grass plants, shrubs < 1.5m, shrubs > 1.5 m and trees. The spreadsheet, VSA-DataSum.xls, performs all the calculations required and shows them at the bottom of the spreadsheet.

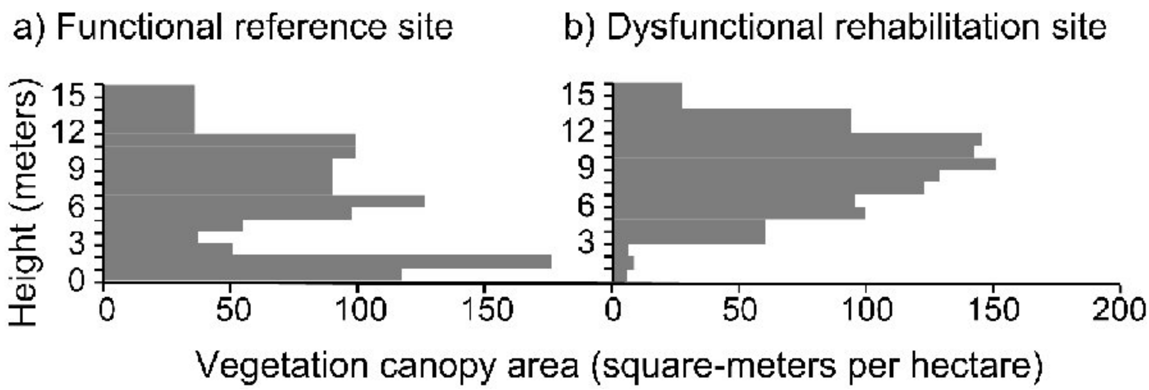

Figure 4. Vegetation foliar cover and height distribution in two woodlands: (a) one in good condition (reference site) and (b) the other in poor condition (dysfunctional site).

The woodland in good condition (Figure 4) illustrates a vertical distribution of canopy cover that would strongly function to resist flows of wind or water through this landscape, hence, would retain vital water and soil resources. In contrast, the woodland in poor condition has a notable loss of ground cover (mainly grasses) and shrubs to about 4 m in height. This has important implications for the flow and loss of soil resources, due to wind and water, across the landscape surface.

The above example illustrates an additional way of using vegetation structure data for a landscape functionality interpretation. It is not intended as a replacement of traditional vegetation composition and biomass estimation methods.

Further remarks

The methods of measuring vegetation structure described above are conventional, but by linking these structural data to the landscape and to soil indicators is an important feature of landscape function analysis (LFA). For example, by combining data from vegetation dynamics and soil surface indices, one can specify the edaphic habitat or "habitat quality" for species of interest. Data from reference sites, or those unaffected by disturbances, can provide perspective for assessing how close a rehabilitated site is to the edaphic habitat illustrated by the reference area; this perspective is discussed in Chapter 3 of "Restoring Disturbed Landscapes".

Monitoring restoration sites is critical because changes in any of the vegetation structure indices (e.g., vertical canopy cover profiles) between monitoring times will strongly reflect how rehabilitated sites are developing toward reference sites in terms of the functional role of the vegetation.

References

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