LANDSCAPE FUNCTION ANALYSIS

SOIL SURFACE ASSESSMENT CRITERIA

The nature, meaning and scope of each surface feature, together with a classification procedure are detailed below.

1. Rainsplash Protection

The objective is to assess the degree to which physical surface cover and projected plant cover ameliorate the effect of raindrops impacting on the soil surface. Raindrops can cause soil erosion by splashing particles or form dense "physical crust", which reduce infiltration.

Assess the combined projected percentage cover of: perennial vegetation to a height of 0.5 m; rocks > 2 cm in diameter; woody material such as branches and bark > 1 cm in diameter; and/or other long-lived, immoveable objects. These objects intercept and break up raindrops, making them less erosive and less liable to form soil physical crusts. This indicator relates to the Stability Index.

What doesn't count:

(i) Ephemeral herbage. This type of material may not be present when rain events are unpredictable such as in the more arid areas.

(ii) Foliage at heights greater than 0.5 m. "Gravity" drops falling from foliage are much larger than raindrops and have higher erosive capacity when falling from heights greater than 0.5m

(iii) Litter. This is assessed separately (Indicator 3) and inclusion here would "double-up" the contribution of litter when calculating the stability index.

Projected Cover	Class	Interpretation
1% or less	1	No rainsplash protection: bare, crusted soil, high run-off
1 to 15%	2	Low rainsplash protection: some woody, stony or live plants will intercept some rain. Soil is crusted
15 to 30%	3	Moderate rainsplash protection: noticeable protective effect, but some crusting
30 to 50%	4	High rainsplash protection: crusting variable or weak
More than 50%	5	Very high rainsplash protection: soil surface not crusted.

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2. Perennial Vegetation Cover

The objective is to estimate the "basal cover" of perennial grass and/or the density of "canopy cover" of trees and shrubs.

This indicator assesses the contribution of the below-ground biomass of perennial vegetation to nutrient cycling and infiltration processes through aboveground measurements. Grass cover is assessed by summing the **butt diameters** of perennial grass plants on the query zone mini-transect. Tree and shrub cover is assessed from the cover and density of the canopy overhanging the query zone.

Basal and Canopy Cover	Class	Interpretation
1% or less	1	Very low root biomass likely
1 to 10%	2	Low root biomass due to a number of small plants
10 to 20%	3	Moderate root biomass due to medium sized plants
More than 20%	4	High root biomass, due to large plant presence

What is not included:

All non- perennial plants. The contribution of non-perennial plants is included in the Litter indicator. Some bi-annual and annual grasses may be robust enough to act as pseudo perennials. The decision to include them in the assessment will depend on 'local knowledge' of the biology of the species. It is essential to be consistent across monitoring rounds. Use the "notes" column on the data sheet to indicate what decision has been made about a particular species functional role.

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3. Litter

The objective is to assess the amount, origin and degree of decomposition of plant litter, to assess nutrient cycling

"Litter" refers to annual grasses and ephemeral herbage (both standing and detached) as well as the detached leaves, stems, twigs and fruit of perennial species and animal dung, etc.

This indicator is strongly related to the concentration of carbon, nitrogen and other elements stored in the surface soil layers.

Note: recent fire usually eliminates litter, temporally decreasing the nutrient cycling index, as it relies strongly on the litter indicator. Unless the effect of the fire itself is being assessed a period of at least one growing season should elapse before assessing burnt sites. This should remove a potential negative "spike" in the data.

There are three properties of litter that need to be assessed in the following order:

(i) **The cover** (in 10 classes) as per the table. When litter is more than 100% cover, the depth is assessed my compressing it with the flat of your hand to remove "air-gaps".

% Cover of plant litter	Class
<10	**1**
10-25	**2**
25-50	**3**
50-75	**4**
75-100	**5**

100 up to 20 mm thick	**6**
100, 21-70 mm thick	**7**
100, 70-120 mm thick	**8**
100, 120-170 mm thick	**9**
100, > 170 mm thick	**10**

(ii) **The origin** of the litter:

Litter Origin	Class
local **(l)** = derived from plants growing in very close proximity to the query zone and showing no signs of transport/deposition by wind or water flows	**l**
transported (t) = litter has clear signs of being washed or blown to the current location.	**t**

Litter patches in the surrounding landscape may assist in defining the origin of litter in the query zone (where they may be associated with parent plants or transported to a location where litter accumulates).

(iii) **The degree of decomposition/incorporation** in 4 classes:

Litter Origin	Class
Nil decomposition (n): the litter is loosely spread on the surface with few, if any, signs of decomposition and incorporation.	**n**
Slight decomposition (s): litter is broken down into small fragments and intimately in contact with soil; some fragments may be partially buried.	**s**
Moderate decomposition (m): litter is in several distinct layers; some fungal attack is visible; the layer next to the soil is somewhat humified; some darkening of the soil to a depth of less than 10 mm.	**m**
Extensive decomposition (e): litter has at least 3 layers or stages in decomposition ranging from fresh material on top to 20 mm or more of comprehensively humified (very dark, with no identifiable fragments) at the soil-litter interface; mineral soil may have significant organic darkening in excess of 10 mm.	**e**

Litter assessment examples

- 25-50% cover, local origin, slight decomposition is recorded as 3ls
- 100% cover but less than 20 mm thick, local origin, moderate decomposition is recorded as 6lm
- 10-25% cover, transported, nil decomposition is recorded as 2tn

Write the full coding into the SSA data-sheet and also type into the Excel SSA template.

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4. Biological Soil Crust Cover

The objective is to assess the cover of biological soil crusts (BSCs) visible on the soil surface.

For the purpose of this assessment, BSC is a generic abbrebiation that includes cyano-bacteria, algae, fungi, lichens, mosses, liverworts and fruiting bodies of mycorrhizas. When these are present, they indicate soil surface stability and elevated concentrations of available nutrients in the surface layers of soil. They are known to exchange minerals and water with vascular plants in return for carbohydrates.

Typically (though not exclusively), they colonise soils with pre-existing stable physical crusts. They tend to impart flexibility to the physical crust, due to the ramification of hyphae through the surface few mm. BSCs may be early colonisers of recovering soil surfaces, but may later decline as vascular plant cover increases. Typically, they need high light levels to persist and are seldom found under dense, particularly woody, litter. They have been observed under light grassy litter and shallow sandy strews. Soils with physical crusts, in the open, are their typical habitat.

The soil surface may need close inspection to assess the presence of cyano-bacteria, which may appear as black stains. Adding a little water and observing the "greening" of the organisms over a period of 10 –20 seconds can be very useful. Some BSCs may be "detached" from the soil surface after long periods of desiccation, but cover is assessed normally in such a case.

When BSCs are not relevant:
Where the soil surface is clearly mobile, e.g. loose, active sands; "naturally active", e.g. self-mulching clays or has an extensive deep litter cover, no habitat for cryptogams exists and a or zero recording (meaning **not applicable**) should be made. Generally, if Crust Broken-ness (Indicator 5) has been assessed as "zero" (not applicable) then Cryptogam Cover will also be "zero" as it requires a stable surface for them to colonise and persist. In rare cases, lichens can grow on sandy soils, or on undisturbed self-mulching clays. Where this is observed, the cryptogam indicator must be assessed.

Cryptogam Cover	Class	Interpretation
Not applicable	0	No stable soil surface present
1% or less	1	No contribution
1 to 10%	2	Slight contribution
10 to 50%	3	Moderate contribution
More than 50%	4	Extensive contribution

5. Physical Crust (PC) Brokenness

The objective is to assess to what extent the surface crust is broken, therefore to what extent loosely attached soil material is available for erosion.

A crust is defined as a thin, dense physical surface layer that overlies sub-crust material. Physical crusts in good condition are smooth and conform to the gentle undulations in the soil surface. Such crusts yield little soil material in a runoff event, but do restrict infiltration.

However PCs can become unstable, brittle and easily disturbed by grazing animals, the materials then becoming available for wind or water erosion. Typically sections of crust are lost, forming a micro-crater that may be filled with loose alluvium. Both the area and severity of broken crust need to be assessed. Fine polygonal cracking of the crust without curled-up edges is not considered broken and scores 4, the maximum value.

When crust broken-ness is irrelevant:
Record "Zero" in the following circumstances.

- Loose, sandy soil
- Self-mulching (surface crumb-structure) clay soils
- Soil under high, permanent perennial plant cover (no crust present, typical under permanent total litter cover)
- When less than 25% of the 1-m line transect is crusted

Crust Brokenness	Class
No crust present	0
Crust present but extensively broken	1
Crust present but moderately broken	2
Crust present but slightly broken	3
Crust present but intact, smooth	4

6. Soil Erosion Type and Severity

The objective is to assess the type and severity of recent/current soil erosion i.e. soil loss from the query zone.

Erosion in this context refers to accelerated erosion caused by the interaction of management and climatic events, rather than the background levels of geologic erosion.
There are five distinct types of soil erosion (see box) that are caused by water and/or wind action. It is useful to note which type or types are active and how serious is the soil loss. This involves both the aerial extent and the severity. The Australian conventions and definitions are used.
Sometimes the erosion occurred at some time in the past and spontaneous restoration has since taken place. For example; rill edges may be rounded or terracettes may have cryptogam colonization (example) in these cases, reduce the severity by one class.

Forms of Erosion

Five major forms are described here enabling the form/s of erosion on the query zone to be determined.

Sheeting, or **sheet erosion (E)** is the progressive removal of very thin layers of soil across extensive areas, with few if any sharp discontinuities to demarcate them.
This is not always easy to detect with assurance, and may need to be inferred from other soil surface features, such as downslope alluvium, or surface nature. It is sometimes confused with scalded surfaces, but characteristically is associated with gradational or uniform textured soils.

Many sheeted surfaces are covered by layers of gravel or stone (collectively called "lag") left behind after erosion of finer material, when at an advanced stage.

Pedestalling (P) is the result of removing soil by erosion of an area to a depth of one to several cm, leaving the butts of surviving plants on a column of soil above the new general level of the landscape. Exposed roots are a hallmark of this erosion form. This is a sign that the soil type itself is very erodible and that loss of vegetation in the landscape was preceded by erosion, and not the other way about. Often associated with an inadequate stone cover in the post mining environment.

Rills and gullies (R) are channels cut by flowing water. Rills are less then 300 mm deep and gullies are greater then 300 mm deep (*Australian Definition*). They may be initiated by water flowing down sheep or cattle paths. Their presence is a sure sign that water flows rapidly off the landscape, often carrying both litter and soil with it. They are aligned approximately with the maximum local slope.

Terracettes (T) are abrupt walls from 1 to 10 cm or so high, aligned with the local contour,. Terracettes progressively cut back up-slope, the eroded material being deposited in an alluvial fan down-slope of the feature. The location of a terracette should be noted in the comments of the landscape organisation sheet for the gradsect so that its progress upslope can be monitored over time. A change of zone will occur at the location of the terracette and it is assessed as occurring in the upslope zone (i.e. it will have a Erosion type and Severity class value of 1 or 2. The erosion type downslope of the terracette may be sheeting with alluvial deposits. Erosion scarps have a similar appearance, but are caused by erosive forces from downslope, such as wave action on a lake shore, rather than down-slope water flow

Scalding (S) is the result of massive loss of A-horizon material in texture-contrast soils which exposes the A2 or B horizon which are typically very hard when dry and have extremely low infiltration rates. Scalds have a productive potential of zero, and pond or shed water readily. They are often on flat landscapes, though not exclusively, whereas sheeting is on gentle slopes.

Erosion 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	**2**	**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**

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7. Deposited Materials

The objective is to assess the nature and amount of alluvium recently transported to and deposited within the query zone.

The presence of recently transported soil and litter materials on the query zone indicates that instability upslope has permitted loose material to be transported to the query zone. Silts, sands and gravels usually comprise the alluvium. Absence does not necessarily imply a lack of deposition, as erosion may sweep all these materials out of the system. Alluvial fans can quickly become quite stable and productive, depending on the stress and disturbance impacting on the surface. An alluvial fan may become a productive patch within a short time if the right seasonal conditions occur. The amount or volume of deposited material is more important than the simple cover.

Hummocking is an indication of the movement large quantities of materials by wind. It is not to be confused with pedestalling which is the eroding away of material around plants and other objects. It is most often associated with adjacent scalding.

Hummocking is confined to soils with sandy-textured surface layers and is the result of saltation and re-sorting of sand by wind, which accumulates around obstructions, often to depths of many centimetres, or even metres.
The soil in the hummock is unconsolidated, and if sectioned reveals layers of accumulated soil and/or organic matter. The soil in pedestals on the other hand, is coherent and has no sign of layering.
A consequence of hummocking is that fine-grained materials and litter maybe widely dispersed during windy phases and are lost to the system. It is rare in the tropical grasslands.

Deposited Material	**Class**
Extensive amount present. Greater then 50% cover, several cm deep	1
Moderate amount of material present 20 to 50% cover, significant depth	2
Slight amount of material present, 5% to 20% cover	3
None or small amount of material present, 0-5% cover or a “dusting” of loose material	4

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8. Soil Surface Roughness

The objective is to assess the surface roughness for its capacity to capture and retain mobile resources such as water, seeds, topsoil and organic matter.

Surface roughness may be due to depressions in the soil surface which retain flowing resources (depressions, gilgais etc) **or** to high grass plant density such that water flows are slowed and highly convoluted at the 5-cm horizontal scale. High surface roughness reduces outflow rates, permitting a longer time for infiltration and may comprise a safe site for the lodgment of seeds and litter. Soil surface relief that does not facilitate resource retention attracts low scores (eg stones with no captured resources)

Surface roughness	**Class**
< 3 mm relief in soil surface. Smooth: little or no retained materials	1
Shallow depressions 3-8 mm relief; sparse vegetation Low visible retention	2
Deeper depressions 8-25 mm or grass plants growing close together. Moderate visible resource retention	3
Deep depressions that have a visible base; very large grass tussocks. Substantial visible retention	4

Very deep depressions or cracks >100mm. Gilgai depressions Extremely high retention and storage.	5

9. Surface Nature (coherence or resistance to disturbance when dry**)**

The objective is to assess the ease with which the soil can be physically disturbed to release material suitable for removal by wind or water.

- This assessment should only be done on dry soil, as all moist soils are soft. All the criteria below presume dry soil is being assessed. <u>If the local climatic conditions do not allow the soil to dry out, a sample can be collected and dried under cover for later testing.</u>

- A very hard soil surface implies high mechanical strength, but very low infiltration, due to low porosity and massive crusting or "hard setting". This is taken into account by the Excel template which weights the stability and infiltration indices appropriately via the automated algorithms.
- Crust flexibility and coherence are assessed, as per the table. Note that classification here is not necessarily intuitive: barren, hard scald surfaces are classified 4. The spreadsheet deals with this apparent anomaly with appropriate re-scaling based on values that would be recorded for other indicators.

Surface Nature	Class	Interpretation
Non -brittle	5	Soft, but shows some "springiness" when pressed with finger, typically with A_0 layer and buried litter; **or** Surface is a self-mulching clay; **or** Surface has no physical crust and is under a dense perennial grass sward (i.e. not just an isolated plant).
Crust is very hard and brittle	4	Needs a metal implement to break the surface, forming amorphous fragments or powder. The sub-crust is also very hard, coherent and brittle.
Moderately hard	3	Surface is moderately hard, may have a physical crust, and needs a plastic tool (e.g. pen-top) to pierce, breaking into amorphous fragments or powder; the sub-crust is coherent.
Easily broken	2	Surface is easily penetrated with finger pressure (to about first knuckle joint). Surface may have a weak physical crust and sub-crust is non-coherent *e.g.* sandy.
Loose sandy surface	1	Surface is not crusted, easily penetrated by finger pressure to about second knuckle joint. Sub-surface soil is non-coherent.

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10. Slake Test (coherence under wetting)

The objective of this test is to assess the stability of natural soil fragments when rapidly wetted.

The test needs to be done on each patch and inter-patch type identified. Stable soil fragments maintain their cohesion when wet, implying low water erosion potential. The test is performed by gently immersing **air-dry soil fragments** of about 1-cm cube size **in rain quality water** and observing the response over a period of a minute or so. . If local climatic conditions restrict availability of dry soil, samples can be collected and dried for this test.

- Water quality is important.
- Saline water is unsuitable.
- The soil crust must remain uppermost after immersion.

The fragment can be obtained with a chisel or knife blade, breaking the fragment with the fingers to the appropriate size. Some soils with high organic matter levels may float in the water. Usually, these are stable (Class 4). Soils that do not permit coherent fragments to be picked up and tested (e.g. loose sands) should be scored as “not applicable” (record zero in the spreadsheet).

Exclusions:- Do not test moist soil. Take a samplehome, allow it to air-dry, then test

Observed Behaviour	Class	Interpretation
Not Applicable	**0**	No coherent fragments available to test. e.g. loose sand
Very unstable	**1**	Fragment commences slumping in less then 5 seconds, eventually becoming a shapeless mass. Very fine air bubbles may emerge
Unstable	**2**	Fragment substantially slumps in 5-10 seconds but a thin surface crust remains: >50% of the sub-crust volume slakes
Moderately stable	**3**	Surface crust remains intact with some slumping of the sub-crust but less then 50% of the volume
Very stable	**4**	Whole fragment remains intact with no swelling. Large air bubbles may emerge

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11. Soil Surface Texture

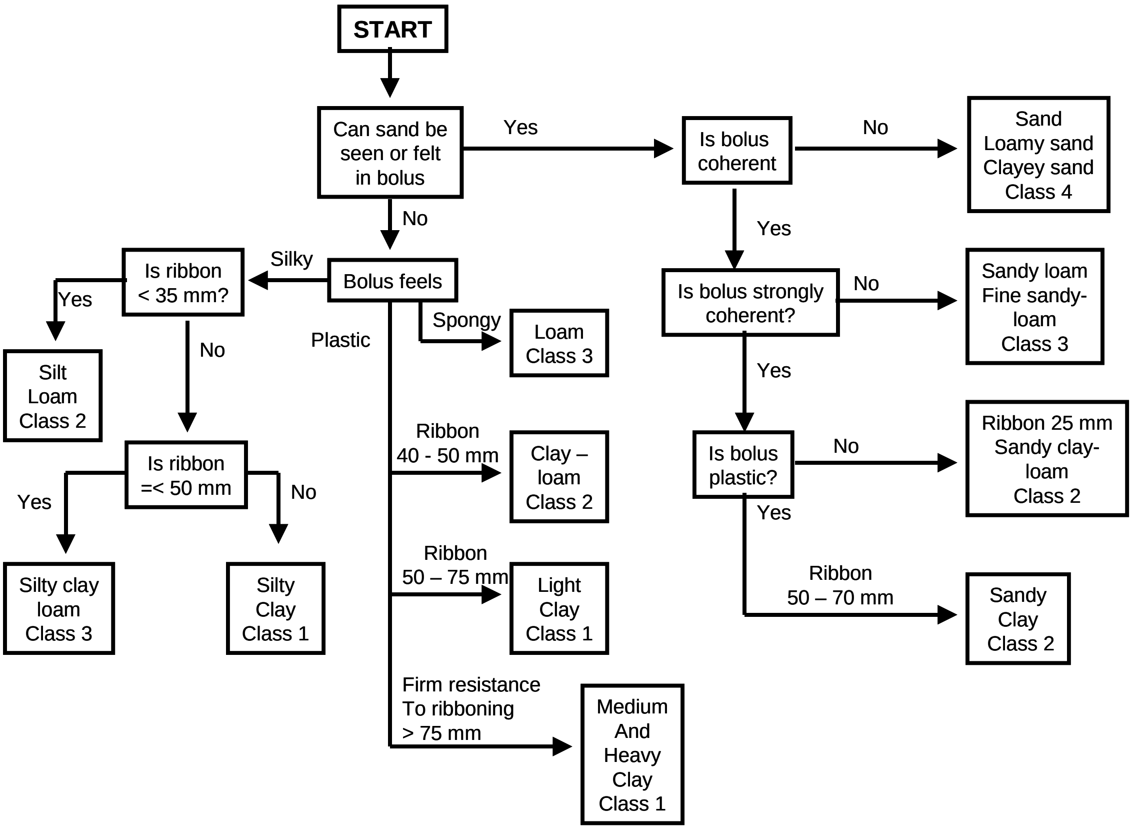
The objectives of this test are to assess the texture class of the surface soil as it affects infiltration.

This procedure is an initial measurement at the establishment of the site, and does not require being repeated at each monitoring event. The field technique is as follows: *Take a sample of soil from a depth of 0-1 cm that will comfortably fit into the palm of the hand. Moisten the soil with water, a little at a time, and knead until the ball of soil, so formed, just fails to stick to the fingers. Add more soil or water to attain this condition, known as the sticky point, which* *approximates field capacity for that soil. Continue kneading and moistening until there is no apparent change in the soil ball, usually 1-2 minutes.*

The behaviour of the soil ball, or bolus, and the ribbon it produces by pressing out between the thumb and forefinger characterizes the field texture.

The flow-chart below enables soil texture indicator to be quickly determined.

Exception: Self-mulching, cracking clays should be recorded as class 3, because of their moderate infiltration rate



Soil Texture Flow Chart.