Reading the Landscape:

The Rapid Assessment of Soil Health

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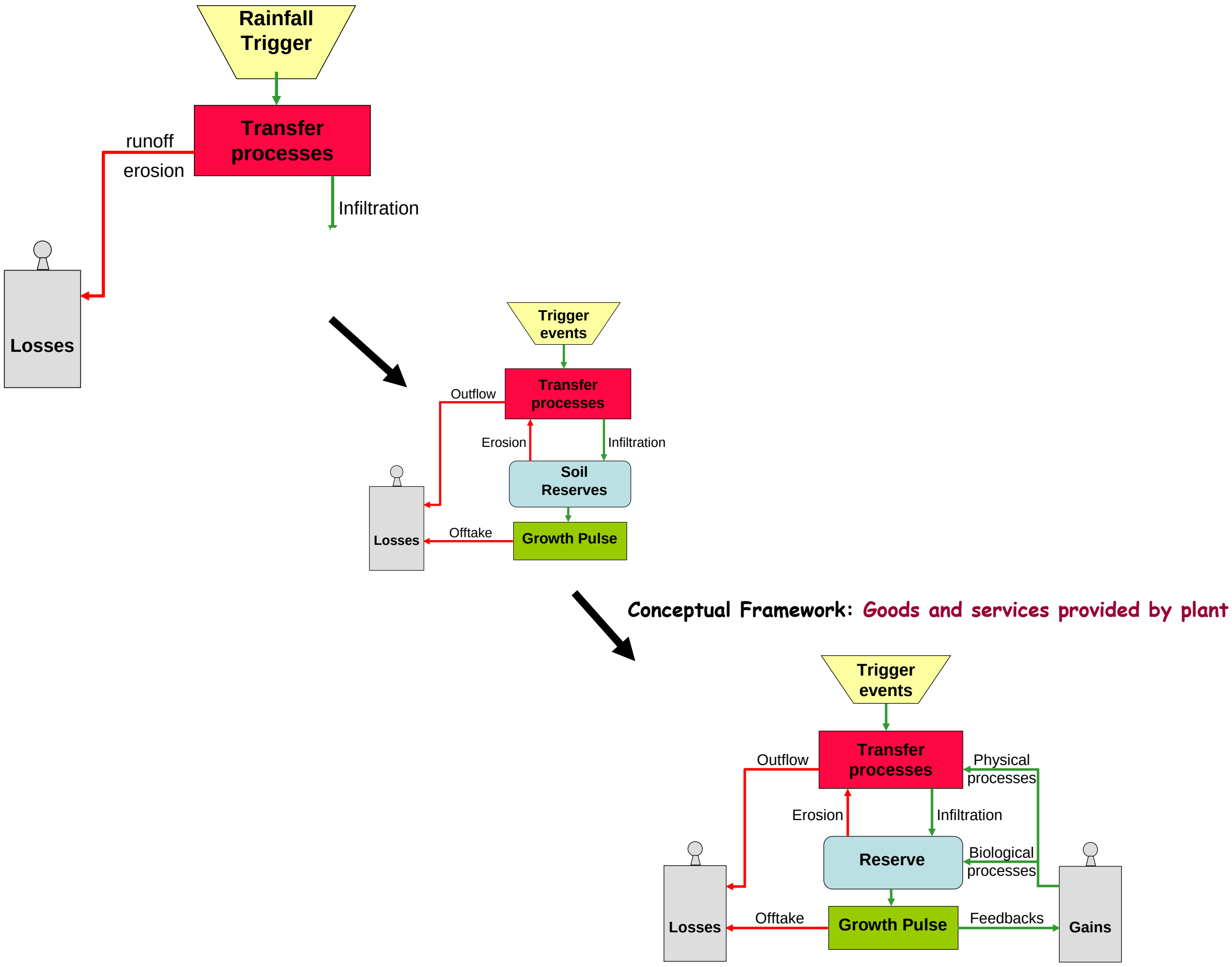
Introduction

- **Landscapes** are areas of interconnected ecosystems.
- **An ecosystem is**:- "An interdependent and dynamic system of living organisms with their physical and geographical environments"
- **Reading the Landscape** originated in the study of natural landscapes, examining how they worked as biophysical systems, rather than listing their components.
- Landscapes in "good health" make effective use of vital resources, such as water topsoil, seeds and organic matter, are characterised as "functional" whereas landscapes in "less healthy" states are characterised as being in some degree of "dysfunction". Landscape functionality can be reduced to:- "the economy of vital resources". (see upcoming diagrams)
- RtL provides a proportional assessment of "healthiness": eg does the landscape have a "common cold" or "terminal cancer"?
- RtL involves observation of soil surface **processes,** including the goods and services provided by biota of all types.
- This enables the identification of "framework plant species" which can be shown to be providing the majority goods and services to the landscape.
- This is the formalisation of "common sense", but has the advantage of providing numbers that can be compared over time to examine trend or proximity to "thresholds of potential concern" – TPCs – see later - where marked degradation or marked rehabilitation may occur.
- The observations are made in a logical spatial sequence across the landscape, following the direction of resource movement. (gradsect)

Principles

- **Treating causes, not symptoms**. Healthy or "functional" landscapes tend to retain vital resources, such as water, topsoil and organic matter, whereas unhealthy or "dysfunctional" landscapes tend to lose these resources beyond their boundaries. That is, landscape health can be appreciated in terms of "the economy of vital resources", the key question being: " Are the resources being retained, used and cycled within the local landscape, or do they run out (to some extent) of the local watershed or hillslope?"

- **A Conceptual Framework.** The diagrams below summarises the fate of resources in the landscape in terms of processes.



Field Observations

- The measurement procedure involves **data collection at two scales**: firstly, at coarse scale measuring the location and size of "patches" and "inter-patches", providing a set of indicators representing resource flows: "leakiness indices" are calculated and compared to carefully selected reference sites. Secondly, at fine scale where 11 indicators of soil surface processes are assessed on the patches and inter-patches identified in the coarse scale assessment. These indicators provide *insight* into the soil's productive potential or "health".

- The procedure works by first traversing the landscape in a down-slope (or down-wind) direction, following the path of resource movement and capture, looking for evidence of resource accumulation or mobilisation and transport.
- "Patches" are defined as locations where resources tend to accumulate and "inter-patches" are locations where resources tend to be mobilised and transported away.
- The larger the number or the larger the size and proportion of patches, the more healthy is the landscape, because the "resource control" is higher and resource "leakiness" lower. Some landscapes are made up entirely of patches (eg a forest floor or grassy sward) or of inter-patches (large bare soil areas).
- We may discuss each of the soil surface indicators and explain what they tell you. A spreadsheet on the CD calculates three useful indices of soil health.
- Types of soil erosion at this scale is also noted (eg, sheet, terracette, rill, pedestal)

The field data can be useful at arrange of scales: (i) the individual patch or interpatch, (ii) the comparison of patches vs inter-patches and the comparison across different hillslopes of restoration treatments as a whole.

Stab.= 69.1

Infil. = 39.8

N/C = 31.7

Friable, open-fabric soil a perennial grassland A horizon:

Healthy Soil

Stab.= 43.3

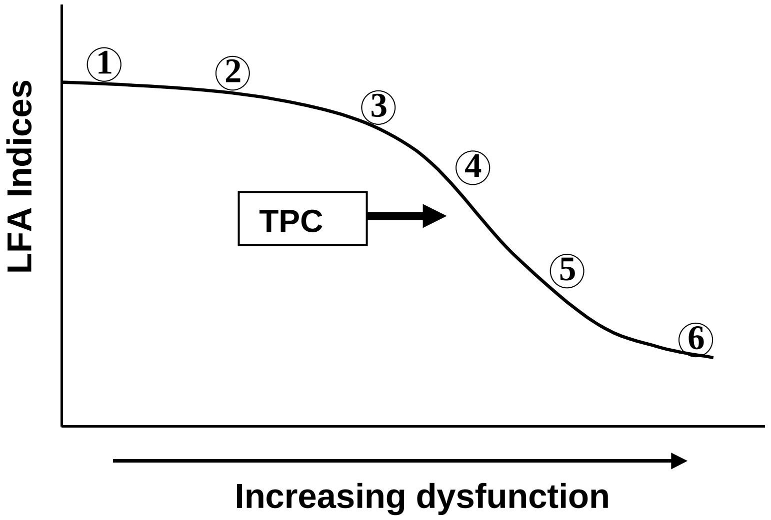
Infil.= 24.0

N/C= 11.5

Bare, crusted, compacted A horizon: no visible biopores

Unhealthy Soil

- **Analysis of the data** permits the determination of "health" by comparing with a reference site. A curve shape as below facilitates the identification of important thresholds or management targets in rehabilitation.



- Sites with values 1, 2 or 3 are highly likely to respond rapidly to removal of stress and disturbance (eg break of drought, adjustment to grazing predation). Values at the location of 4 reflect bare adequacy in terms of landscape "self-sustainability". This is called a **threshold of potential concern**. Landscapes with indices at locations 4 and 5 will require active remediation. Landscapes with indices of 6 urgently need restoration, probably being expensive and/or technically difficult.

State 1 - 2

State 4

State 6

- If health is "inadequate" (index values below the TPC), inspection of the **individual soil surface indicators** will suggest which surface processes need attention and the management actions required (landscape design). This might be as simple as reducing grazing pressure or as complex as making structures to retain a greater proportion of the mobile resources. Costs will obviously vary.
- It is also possible, with experience and the accumulation of data, to simplify the procedure by concentrating on the most informative indicators.
- Often, highly functional landscapes look "untidy" with a number of features scattered about that regulate the outflow of resources. It is also useful if these structures do not allow grazing to ground level.
- The larger and longer-lived the biota, the higher the stored biological resources. Functionality and "buffering" against stress and disturbance varies in the order:- Forests > Woodlands > Shrublands > Grass/sown pasture lands > Cropped lands.

- Uses for RtL data

1. Evaluating deferred grazing effects (how long to rest pasture)

2. Designing appropriate restoration scenarios and technologies when soil erosion is evident (see Restoring Disturbed Landscapes book for examples)

3. Monitoring and evaluating the effect of applied treatments of various types

4. Defining habitat for species of interest ("what landscape function is required to provide adequate habitat for specified species?).

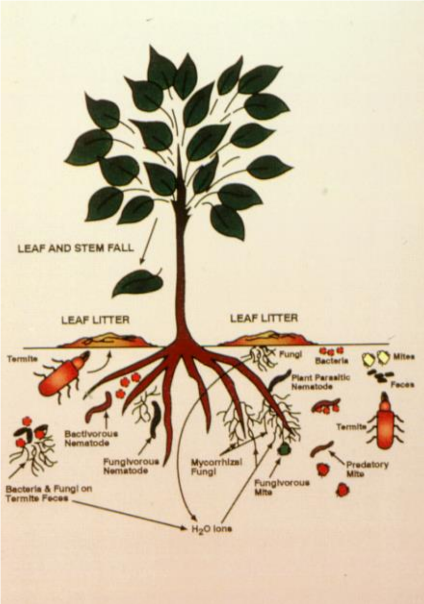
5. Evaluating the functional role of weeds, so as to be able to design weed eradication without giving rise to degradation.

The use of coir "logs" to arrest high-volume overland flow before it enters a gully

Soil Organic Carbon

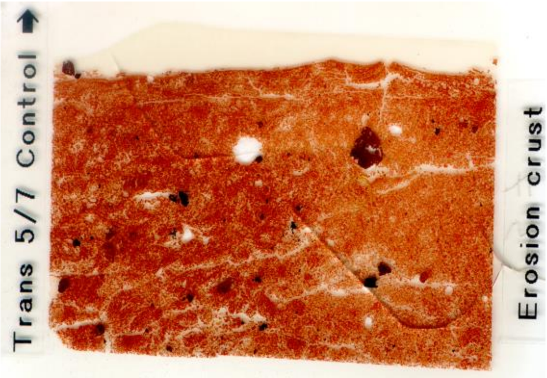
1. Soil organic carbon plays a role in maintaining soil physical, chemical and biological properties:
    - **Physical:** bulk density, infiltration rate, water holding capacity
    - **Chemical**: supply/retention of nutrients in the root zone, cation exchange capacity
    - **Biological**: Soil-dwelling biota (plants, animals and fungi) that break down organic matter to simple nutrients; ecosystem engineering.
2. Organic matter is transported into soil by root exudates of simple, readily metabolised sugars. The image shows sand grains lightly cemented to the roots of a grass plant by sugars, thus reducing moisture loss from the roots and supplying micro-organisms with metabolisable C. This is promptly used by soil microbes as their sole energy source.

3. Plant litter and dead roots are decomposed by a succession of flora and fauna into humified organic material that binds to soil particles, making them highly cohesive. Some "woody" litter compounds may persist for over 1000 years in the soil.

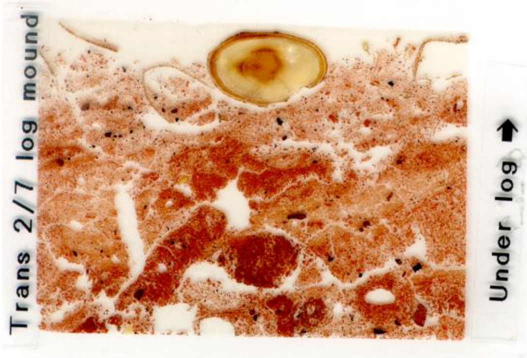


4. Soil organic carbon can be lost by:
    - photochemical oxidation in sunlight. This is especially severe in bare, ploughed paddocks. This can result in hard **physical crusts** that lower seedling emergence, and/or **hard-setting**, lower water infiltration rates, lower water holding capacity and increased erodability (slake test). Because of the disappearance of "food" for soil-dwelling organisms, their populations will decline and their activities diminish (eg "bio-turbation"- Nature's plough). See images of healthy and unhealthy soils above

- A switch from perennial plants to annual ephemeral plants and/or persistent grazing down which reduces both the flow and accession of carbon and the quality of carbon compounds. Perennial plants photosynthesise whenever there is rain, transferring C into the roots, whereas annual plants have a "programmed life-span so that after death, no more active C is translocated into the roots. A second effect is creating nitrogen immobilisation periods, when rain will not trigger growth because mineral N is not available.
- Death of pasture plants, which ceases the flow of C, which "starves" the soil microbes.
- Erosion of topsoil and its removal out of the local watershed.



Inactive carbon accession



Active carbon succession