Department of Science, Information Technology, Innovation and the Arts

Mapping erodible soils in Burdekin Dry Tropics grazing lands

Userguide to datasets

Soil and Land Resources, Science Delivery

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The Department of Science, Information Technology, Innovation and the Arts (DSITIA) mapped the soils across the Burdekin Dry Tropics for their inherent vulnerability to erosion in a project under the Department of Environment and Heritage Protection's (EHP) Reef Water Quality (RWQ) program.

Inherently vulnerable soils are soils prone to slaking and dispersion and when detached, have the potential to travel off-site and be transported to waterways.

This project has developed a spatial dataset that maps;

- surface soil vulnerability
- subsoil vulnerability and
- overall inherent vulnerability to erosion (composite summary dataset)

An abridged version of this data set can be viewed using the FORAGE online reporting system on The Long Paddock website. www.longpaddock.qld.gov.au/forage/

The dataset has been produced at a sub-catchment scale and can be used to identify potential sediment sources, provide improved soil and landscape data to help predict areas vulnerable to erosion and improve pollutant load estimates.

This user guide outlines what inherently vulnerable soils are, how they have been mapped and how the data can be used.

This guide has been written to support the understanding and interpretation of the datasets, and should be read in conjunction with the data.

Introduction

The Burdekin River is the source of the largest proportion of sediment that reaches the reef lagoon (Kroon *etal.*, 2010). Most of the sediment within the catchment comes from the Upper Burdekin and Bowen rivers with less than 5% from the Cape, Belyando and Suttor rivers. The Cape, Belyando and Suttor rivers contribute a disproportionately high amount of fine grained sediments (clay sized) to the lagoon.

Soil erosion processes vary greatly across the catchment and are influenced by the type of soil, degree of land cover, climate (seasonal and long term trends), terrain and land management practices. This assessment of *Spatial predictions of soil erosion attributes in the Burdekin Catchment* has mapped the different soils based on how inherently vulnerable they are to erosion. Other Reef Water Quality Science projects are mapping presence of gullies, producing ground cover reports and tracing sediment sources and processes in the catchment.

What is a ‘soils inherent vulnerability to erosion’

A soils inherent vulnerability to erosion is its susceptibility to detachment and transportation by erosive agents. It is a composite expression of those soil properties that affect the behaviour of a soil and is a function of the mechanical, chemical and physical characteristics of the soil. It is independent of the other factors influencing soil erosion such as topography, land use, rainfall intensity and plant cover, but may be changed by management. The most highly erodible soils are those that are most easily detached and transported by erosive forces. High soil dispersibility is a good indicator of high soil erodibility (after Houghton and Charman, 1986).

The other factors are also important influences on how much erosion actually occurs but they have not been taken into account in this dataset. Information on these additional drivers of erosion are available for the Burdekin in the form of digital elevation models (DEM), land use, climate data and land cover.

This data set does not indicate or map actual soil erosion and hence users should not see or describe this work as erosion mapping.

How the dataset was made

To map inherent vulnerability to erosion, a classification has been developed using soil attributes that are specifically relevant in the Burdekin catchment (Table 1).

Table 1. Summary of soil attributes used to classify a soils inherent vulnerability to erosion in the Burdekin.

Soil attribute	Relevant soil layer	Description of significance
Clay %	Surface soils and subsoils	Indicates the overall soil texture and is used in surface layers to separate out sandy surface soils (clay < 20%; sandy loam or lighter) that are non-cohesive. In subsoil layers, clay % is used to prevent erroneously high ESP values in sandy soils (soils containing less than 10% clay such as loamy or clayey sands or sand are excluded).
Clay activity	Surface soils	Indicates the possible clay mineralogy. Dispersion is most pronounced in swelling clays (clay activity > 0.6) and least pronounced in kaolin dominated clays (clay activity <0.5) (FAO 1985).
Exchangeable Sodium Percentage (ESP)	Surface soils and subsoils	Is an indication of sodicity, it measures the dominance of sodium ions on the clay exchange of the colloid. Clays dominated by sodium ions are much less stable and more likely to disperse than clays dominated by calcium ions. Critical value for surface soils is ESP ≥ 6% and for subsoils ESP ≥ 15%.
Electrical conductivity (EC)	Subsoils	Presence of salts in the soil solution can flocculate clays that would or have dispersed due to sodium domination of the clay exchange sites, thus making soils less dispersive. The critical value used is EC >0.5 dS/m.
Calcium/magnesium ratio (Ca/Mg)	Subsoils	Indicates the relative dominance of magnesium ions on the clay exchange of the colloid. Magnesium cations on the exchange reinforce the dispersive effect of sodic clays and hence soils are even less stable and more dispersive. Critical value used is Ca/Mg < 1.

This classification considers surface soil and subsoil horizons separately with a composite layer summarising the entire soil profile. Because different processes drive aggregate stability down the profile, different soil attributes are considered for surface and subsoil horizons.

Data used

Soil data used for these maps has come from more than 8000 existing soil profile observations collected over the past 60 years. An additional 400 sites have been observed and sampled in areas with few existing sites. Specific soil attributes that are relevant to mapping inherent vulnerability to erosion were selected from the soil data set (Table 1). The data has been harmonised and interpolated using digital soil mapping (DSM) techniques to produce spatial datasets across the entire catchment. For detailed information on the methodology used, please refer to the related Technical Report for this project.

Surface soil stability

Surface soils can provide a protective cap over most erodible subsoils. When this horizon is disturbed or removed, subsoil erosion may occur. Maintaining surface soil is vital however, some surface soils are more stable than others. Figure 1 demonstrates the role a stable surface soil can have in protecting the soil. In this case the surface soil above the line has prevented the dispersive subsoil below from eroding. Further information on erosion processes is available at www.qld.gov.au/environment/land/soil.

This classification of surface soil stability attempts to differentiate between less stable and more stable surface soils. Soil texture (clay %), soil sodicity (ESP) and clay type (Clay activity) have been used to make this assessment. A tree based model with critical values has been used to determine each category as shown in Figure 2.

Figure 1. Stable soil over a dispersive subsoil

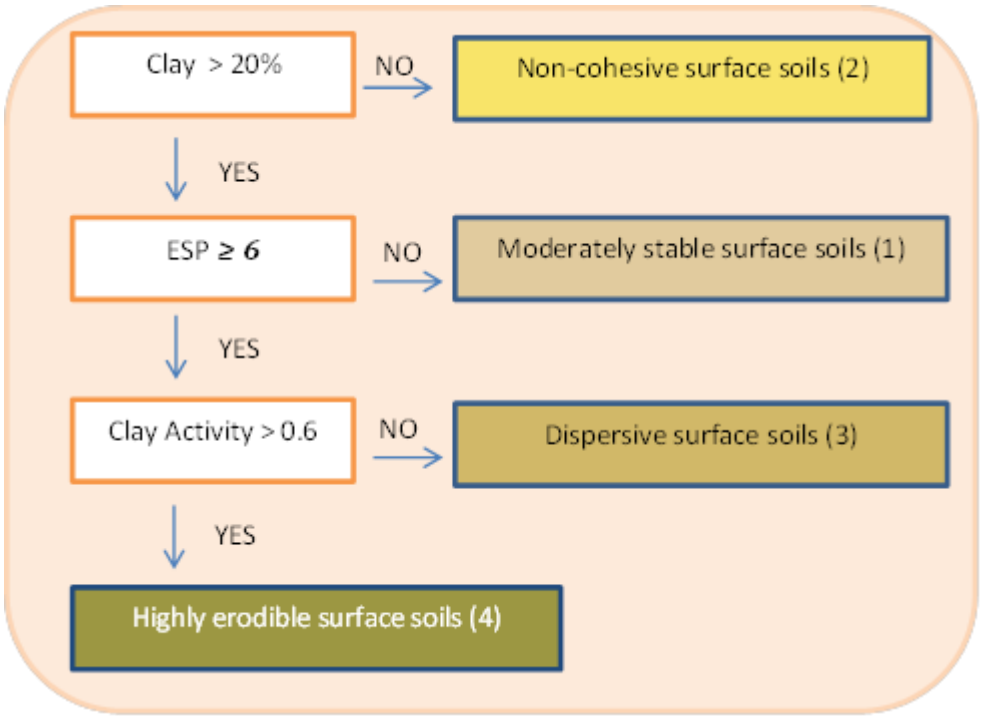

Figure 2. Surface soil erodibility decision tree

The surface soil categories are,

1. Moderately stable surface soils – soils that are unlikely to be dispersive. These are usually well-structured and resilient to degradation.
2. Non-cohesive surface soils– sandy soils that are non-structured or only weakly so and non-cohesive. These soils are easily eroded.
3. Dispersive surface soils – loamy or clayey soils that are sodic, hardsetting and likely to disperse in water.
4. Highly erodible surface soils – clay soils that are sodic and dominated by expanding/swelling clays that disperse readily.

Subsoil dispersibility

Gully and bank erosion rates are influenced by how dispersible subsoils are. The more dispersible, the greater the vulnerability to gully erosion. Figure 3 shows an area where the surface soil has eroded and the dispersible subsoil has gullied and in parts completely washed away. The pale areas are mainly fine sand that has remained after the lighter clay and silt particles have washed away. Further information on erosion processes is available at www.qld.gov.au/environment/land/soil.

Figure 3. Photo showing a dispersive subsoil

Subsoil dispersibility has been categorised using soil texture (Clay %), soil sodicity (ESP), soil salinity (EC) and how magnesic subsoils are (Ca/Mg). A tree-based model with critical values has been used to determine each soil category (Figure 4).

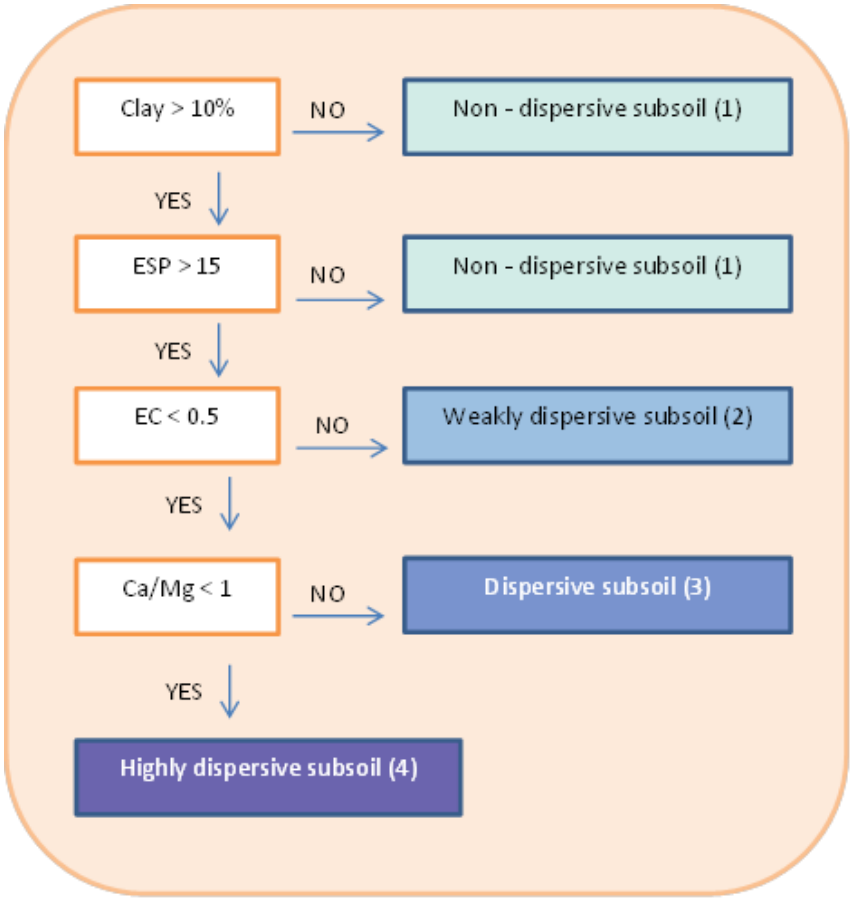

Figure 4. Subsoil dispersibility decision tree

The subsoil categories are,

1. Non-dispersive subsoils – subsoils that are non-sodic or only weakly sodic and are unlikely to disperse.
2. Weakly dispersive subsoils – sodic subsoils that are saline or dominated by carbonate nodules that prevent these subsoils from dispersing readily.
3. Dispersive subsoils – sodic subsoils that disperse readily.
4. Highly dispersive subsoils – sodic soils that are also dominated by magnesium ions that enhance the dispersive affect.

Overall inherent vulnerability to erosion

A soils overall inherent vulnerability to erosion is a combination of the stability of the surface soil and the dispersibility of the subsoil. For example, Figure 5 shows a soil with a moderately stable surface soil over a dispersible subsoil. The soil has eroded away from areas where the surface was not stable to expose the subsoil to erosion. In areas where the surface is stable it remains, providing a protective layer over the subsoil.

Soil surface stability and subsoil dispersibility have been combined into 17 categories. These categories have been ranked using expert knowledge, the higher the number the greater the overall inherent vulnerability to erosion. Table 2 shows how these combinations were determined and their assigned rank and Table 3 describes the 17 categories.

Figure 5. Photo of a stable soil overlying a dispersive subsoil

Table 2. Overall inherent vulnerability to erosion based on surface soil stability and subsoil dispersibility

Subsoil dispersibility	Surface soil stability: Moderately stable surface soils	Non-cohesive surface soils	Dispersive surface soils	Highly erodible surface soils
No subsoil	1	5	11	8
Non-dispersive subsoils	2	4		14
Weakly dispersive subsoils	3	7		
Moderately dispersive subsoils	6	10	13	16
Highly dispersive subsoils	9	12	15	17

In addition to these simplified categories a more comprehensive dataset has been created that also takes into account the surface horizon thickness and includes 60 individual classes. Soils with thinner surface horizons are more vulnerable to erosion than those with thick surface horizons. Surface thickness has been categorised into,

Thin (3) – 0-0.1m; Medium (2) – 0.1-0.3m; Thick (1) - >0.3m.

In addition to the inherent vulnerability to erosion dataset individual soil attribute layers at five or six soil depths are available on request from DSITIA.

Table 3. Legend descriptions for overall inherent vulnerability to erosion.

Very low erosion vulnerability		
1	Moderately stable surface soils over rock	loamy or clayey soils over rock or alluvial sediment
2	Moderately stable surface soils over non-dispersive subsoils	loamy or clayey soils over non-dispersive subsoils
3	Moderately stable surface soils over weakly dispersive subsoils	loamy or clayey soils over weakly dispersive subsoils
Low erosion vulnerability		
4	Non-cohesive surface soils over non-dispersive subsoils	sandy massive surface soils over non-dispersive subsoils
5	Non-cohesive surface soils over rock	sandy massive surface soils over rock or alluvial sediment
6	Moderately stable surface soils over moderately dispersive subsoils	loamy or clayey soils over moderately dispersive subsoils
7	Non-cohesive surface soils over weakly dispersive subsoils	sandy massive surface soils over weakly dispersive subsoils
Moderate erosion vulnerability		
8	Clayey soils that erode and/or slake readily	clay soils that are sodic and dominated by expanding/swelling clays that disperse readily
9	Moderately stable surface soils over highly dispersive subsoils	loamy or clayey soils over highly dispersive clayey subsoils
10	Non-cohesive surface soils over moderately dispersive subsoils	sandy massive surface soils over moderately dispersive subsoils
11	Weakly dispersive clayey soils	loamy or clayey soils that are sodic throughout the profile, have hardsetting surfaces and are weakly dispersive
High erosion vulnerability		
12	Non-cohesive surface soils over highly dispersive subsoils	sandy massive surface soils over highly dispersive subsoils
13	Dispersive clayey soils	loamy or clayey soils that are sodic throughout the profile, have hardsetting surfaces and are moderately dispersive
14	Clayey surface soils that erode and/or slake over weakly dispersive subsoils	clay soils that are sodic and dominated by expanding/swelling clays that have weakly dispersive sodic subsoils
Very high erosion vulnerability		
15	Dispersive clayey surface soils over highly dispersive subsoils	loamy or clayey surface soils that are sodic and hardsetting over highly dispersive clay subsoils
16	Clayey surface soils that erode and/or slake over moderately dispersive subsoils	clay soils that are sodic and dominated by expanding/swelling clays that have moderately dispersive sodic subsoils
17	Clayey surface soils that erode and/or slake over highly dispersive subsoils	clay soils that are sodic and dominated by expanding/swelling clays that have highly dispersive sodic subsoils

How to use the data

The inherent vulnerability to erosion dataset is intended as a tool to inform extension activities and help prioritise investment to prevent or mitigate erosion in the Burdekin catchment. The dataset is most appropriately used

- at a scale of 1:250,000 or smaller which equates to sub-catchment scale.
- the data should be combined with other available information and knowledge such as slope derived from a digital elevation model (DEM), land use, climate data and land cover data to fully assess the risk of soil erosion occurring. For example, areas with a high vulnerability to erosion are unlikely to be eroded if they have low grazing pressures and consistently high ground cover, whereas areas of low vulnerability can still erode under sufficient grazing pressure. Inherent vulnerability to erosion does not equal erosion outcome necessarily.
- Mapping codes (raster values), suggested colour standards (RGB) and legend labels used in the dataset are listed in Appendix 1.

Mapping uncertainty

The surface soil stability, subsoil dispersibility and inherent vulnerability to erosion datasets each have their own level of uncertainty because different soil attribute datasets were used to create each product. In addition to this, for each soil attribute dataset, the uncertainty will increase as depth increases because less soil data is available at greater depths. For further information about the limitations of the mapping refer to the technical report for the project which will be available through DSITIA.

Further information

- This user guide and technical report are available from the Department of Environment and Heritage Protection Library service at http://www.qld.gov.au/environment/library/
- The raster dataset (90m pixels) is available for download from the Queensland Government Information Service at www.data.qld.gov.au.
- An abridged version of the data in the form of ready-made maps of soil erodibility can be requested using the FORAGE Online Reporting Tool at The Long Paddock website www.longpaddock.qld.gov.au/forage/
- Information on soils and soil erosion can be found at www.qld.gov.au/environment/land/soil/

Glossary

Digital Elevation Model (DEM)

A model or three dimensional representation of the earth's surface.

Dispersion

The process through which clay particles are repelled by electrostatic forces and mechanical forces and separate from each other forming a suspension of clay particles in water

Electrical conductivity (EC)

The measurement of how much electricity moves through a solution—the saltier the solution, the more electricity moves through it, and the higher the electrical conductivity reading.

Hardsetting

Soil which is compact and hard upon drying but softens upon wetting

Massive

A soil which appears to be solid or devoid of peds (or aggregates)

Non-cohesive soil

A soil when dry that is not coherent and will fall apart easily. These soils are usually not structured and sandy

Salinity

The presence of soluble salts in soil or water

Sodic

A soil with a high percentage of sodium ions (in soluble or exchangeable form). Sodic soils exhibit predisposition to degradation such as by dispersion when wet and crusting when dry.

Soil erodibility or soils inherent vulnerability to erosion

Susceptibility to detachment and transportation by erosive agents. It is a composite expression of those soil properties that affect the behaviour of a soil and is a function of the mechanical, chemical and physical characteristics of the soil. It is independent of the other factors influencing soil erosion such as topography, land use, rainfall intensity and plant cover, but may be changed by management.

Soil structure

Refers to the way soil particles group together to form aggregates (or peds). These aggregates vary in size and shape from small crumbs through to large blocks. Where there are no peds present, the soil is described as 'structureless' and may be either non-cohesive or loose (single grain) or cohesive (massive).

Soil texture

Refers to the proportion of sand, silt and clay sized particles that make up the mineral fraction of a soil. For example, a light soil refers to a soil high in sand relative to clay, whereas heavy soils have a higher proportion of smaller clay particles.

Subsoil

Usually referred to as the B horizon which can be clay rich, is often less fertile than the topsoil but can hold more moisture

These definitions have been adapted from:

Houghton, PD, Charman, PEV & Soil Conservation Service of New,South Wales (1986). *Glossary of terms used in soil conservation,* Soil Conservation Service of N.S.W, Sydney.

A list of common soil terms is available at www.qld.gov.au/environment/land/soil.

References

Food and Agriculture Organization of the United Nations. Soil Resources, Development and Conservation Service (1985) 'Land Evaluation for Irrigated Agriculture: Guidelines.' (Food and Agriculture Organization of the United Nations: Rome)

Houghton PD, Charman PEV, Soil Conservation Service of New,South Wales (1986) 'Glossary of Terms used in Soil Conservation.' (Soil Conservation Service of N.S.W: <Sydney>)

Kroon F, Kuhnert K, Henderson B, Henderson A, Turner R, Huggins R, Wilkinson S, Abbott B, Brodie J, Joo M (2010) Baseline pollutant loads to the great barrier reef. *Baseline Pollutant loads to the Great Barrier Reef*

APPENDIX 1 – Dataset codes, legends and colours

Surface soil stability dataset

Grid code	Legend label	Map colour (RGB)
0 – No data		255, 255, 255
1	Moderately stable surface soils	214, 190, 133
2	Non-cohesive surface soils	247, 225, 57
3	Dispersive surface soils	191, 162, 55
4	Highly erodible surface soils	115, 115, 0
9	Surface rock	52, 52, 52

Subsoil dispersibility dataset

Grid code	Legend label	Map colour (RGB)
0 – no data	Don’t display	255, 255, 255
1	Non-dispersive subsoils	182, 237, 240
2	Weakly dispersive subsoils	92, 163, 230
3	Moderately dispersive subsoils	34, 89, 199
4	Highly dispersive subsoils	10, 10, 145

Inherent vulnerability to erosion dataset

Forage code	Simple grid code	Full grid code	Legend label	**Map colour (RGB)**
0	0	0 - No data	Don’t display	255, 255, 255
21	1	101, 102, 103	Moderately stable surface soils over rock	118, 219, 211
21	2	111, 112, 113	Moderately stable surface soils over non-dispersive subsoils	152, 235, 159
21	3	121, 122, 123	Moderately stable surface soils over weakly dispersive subsoils	237, 250, 190
22	4	211, 212, 213	Non-cohesive surface soils over non-dispersive subsoils	255, 255, 179
22	5	201, 202, 203	Non-cohesive surface soils over rock	255, 255, 148
22	6	131, 132, 133	Moderately stable surface soils over moderately dispersive subsoils	247, 243, 126
22	7	221, 222, 223	Non-cohesive surface soils over weakly dispersive subsoils	232, 218, 125
23	8	401, 402, 403	Clayey soils that erode and/or slake readily	212, 188, 116
23	9	141, 142, 143	Moderately stable surface soils over highly dispersive subsoils	176, 143, 77
23	10	231, 232, 233	Non-cohesive surface soils over moderately dispersive subsoils	140, 101, 42
23	11	301, 302, 303, 311, 312, 313, 321, 322, 323	Weakly dispersive clayey soils	145, 115, 84
24	12	241, 242, 243	Non-cohesive surface soils over highly dispersive subsoils	150, 138, 149
24	13	331, 332, 333	Dispersive clayey soils	158, 150, 181
24	14	411, 412, 413, 421, 422, 423	Clayey surface soils that erode and/or slake over weakly dispersive subsoils	171, 150, 181
25	15	341, 342, 343	Dispersive clayey surface soils over highly dispersive subsoils	189, 160, 189
25	16	431, 432, 433	Clayey surface soils that erode and/or slake over moderately dispersive subsoils	222, 206, 222
25	17	441, 442, 443	Clayey surface soils that erode and/or slake over highly dispersive subsoils	255, 252, 255
26	18	901, 911, 912, 913, 921, 922, 923, 931, 932, 933, 941, 942, 943	Rock	52, 52, 52