



Manaaki Whenua
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S-map correlation of soils in the Fundamental Soil Layer

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1 Objective

This report documents the translation of information from the Fundamental Soil Layers to a layer linked to soil siblings from S-map.

2 Background

MWLR was asked to provide soil data suitable for use in the MFE Risk Index Tool (RIT) project for all primary production land in New Zealand. The soil data needed to be suitable for modelling nitrogen losses vertically and horizontally on a daily time step within the APSIM model.

The S-map soil database is well suited to provide the required soil data for modelling leaching and runoff in APSIM. Soil profiles in S-map are described according to functional horizons that have been developed to reflect hydraulic conductivity and water storage characteristics. And rigorous models have been developed to estimate soil water holding parameters (McNeill et al. 2018) and runoff curve numbers. A soil library in the format required by APSIM can be generated from S-map. See Vogeler et al. (2022) for more information. S-map data cover most of the New Zealand's highly productive land and around 50% of land suited to primary production.

The Fundamental Soil Layers (FSL), derived from the New Zealand Land Resource Inventory (NZLRI), is the only digital soil coverage of land beyond the boundary of S-map. The NZLRI (Ministry of Works and Development 1979) is a land resource database comprising an inventory of five physical factors (rock type, soil, slope, type and severity of erosion, and vegetation) and a Land Use Capability (LUC) rating. The definition and delineation of the map-unit polygons were based on combining the five factors. The NZLRI was originally compiled at a scale of 1:63,360 (the pre-1979 first edition); there is 1:50,000 coverage for limited areas in the second edition. The soil component is an amalgam of regional soil survey maps and the 1:253,440-scale (one-inch-to-four-miles) General Surveys of North and South Islands.

The NZLRI was later enhanced by the addition of 16 soil properties collectively known as the FSL (Barringer et al. 1998; Wilde et al. 2000). These layers were generated by creating regional legends that were then correlated using the New Zealand Soil Classification (Hewitt 2010) and referenced to the National Soils Database and other relevant data sources. The description of each soil property is limited to five (in most cases) predefined intervals or classes, with the representative value of the soil property being taken as the interval midpoint of the nominated class(es). The FSL information is not suitable for using in APSIM due to the class-based nature of the soil information and the limited set of available soil properties.

Note that all the regional-scale soil maps in the South Island, and many in the North Island, have been superseded by S-map surveys. Thus, most of the area of New Zealand that is classified in this report occurs in land that was covered by the 1:253,440-scale, General Soil Surveys (NZ Soil Bureau 1954, 1968). Soil map units at this scale should be considered as soil-landscape units rather than soil-type units. Only rudimentary soil

information was provided for these soil units in the associated reports. Consequently, there is high uncertainty involved in estimating the FSL soil properties for land beyond the boundary of S-map coverage.

3 Method

MWLR was asked to provide information suitable for APSIM for all New Zealand. There was limited time and resources to undertake this work. The most efficient way to provide APSIM-ready soil information in areas with no S-map coverage, was to classify soil map units from the FSL/LRI into soil groups, and thence to representative soil siblings in S-map.

3.1 Classification procedure

The soil types in the FSL were classified into groups having similar hydraulic functionality; that is, they have similar water storage (profile available water) and hydraulic conductivity.

NB For this reason this map of FSL/LRI that has been translated to S-map siblings should not be used to derive other soil characteristics such as soil fertility or chemical characteristics.

3.1.1 Grouping of Soil Orders

Outlier soil classes – Bare Rock, Saline, Rocky, Alpine, Hydrothermal, Sand dunes – were identified separately. The remaining soils were classified according to the following groups of Soil Orders:

- Organic Soil – these soils have unique water storage and permeability characteristics.
- Gley Soils – these soils have underlying water tables that constrain leaching, promote denitrification, and are susceptible to ponding and runoff.
- Allophanic Soils – these soils have low bulk density and generally have moderate to rapid permeability.
- Pumice soils – these soils have high sand content, low bulk density and moderate to rapid permeability.
- Brown and Podzol Soils – these soils occur in humid areas and have low density in the upper profile and hydrology is mainly controlled by subsoil permeability.
- Pallic, Melanic, and Semi-Arid Soils – these soils occur in subhumid to semi-arid areas and have higher bulk density than Brown and Podzol soils.
- Ultic, Oxidic and Granular Soils – these are strongly weathered soils overlying thick clay mantles.
- Recent and Raw Soils – these soils have weak profile development.

3.1.2 subdivision of Soil Orders:

Soils that perch water. The presence of a perching layer (a layer with extremely slow permeability) has overriding significance in governing leaching, runoff, and denitrification.

Perched soils either have underlying pans or overlie impermeable rock and were separated into three classes – Perched Volcanic, Perched Ultic/Oxidic and Perched Other (the remaining soils). These were identified using the NZSC attributes.

Soils on steep landscapes. Soils on steep slopes (Slopes >25 degrees) were separated because of their high variability, their propensity to transmit water downslope and their susceptibility to erosion. Steep land was identified using the GENSOI attribute.

Soils on Hills. Soils on hilly slopes (16–25 degrees) were separated because of their contact with underlying rock and therefore their greater propensity for runoff. Hill soils over Greywacke were separated from other rocks because Greywacke is generally fractured and facilitates water-flow within underlying rock structure. These were identified using the GENSOI attribute.

Permeability Soils were separated according to the slowest permeability within one metre depth. The classes were rapid (r), moderate (mo), or slow (s). Permeability classes were identified using the PERMEABILITY attribute. Soils with extremely slow permeability were previously separated into perched classes.

Profile available water Soils were separated into three PAW classes. High (h) = >120 mm, medium (me) = 60–120 mm, Low (l) = <60 mm. These were identified using the PAW_MOD attribute.

The attributes used to subdivide each soil class are listed in Table 1. For example, the Gley soils are subdivided by PAW class and permeability, whereas as the Pumice soils are only subdivided by PAW class.

Table 1. Soil groups derived from soil information in the FSL. A 'y' denotes that the soil classification was further subdivided by the soil property

| Soil classification | Permeability (r,mo,s) | PAW (h,me,l) | Greywacke | Hill |
|------------------------------------|--------------------------|-----------------|-----------|------|
| Bare Rock (Brock) | | | | |
| Saline Gley (Sali+Gley) | | | | |
| Saline Recent and Raw (Sali+RcRw) | | | | |
| Rocky (Roky) | | | y | |
| Alpine (Alpn+RcRw) | | y | | y |
| Hydrothermal (Hydr) | | y | | |
| Organic (Peat) | | y | | |
| Fibrous Organic (FibO) | | | | |
| Sand dune (Sand) | | y | | |
| Steep Hydrothermal (Step+Hydr) | | y | | |
| Steep Allophanic (Step+Allo) | | y | | |
| Steep Pumice (Step+Pumc) | | y | | |
| Steep Brown and Podzol (Step+BrPz) | | y | | |

| Soil classification | Permeability (r,mo,s) | PAW (h,me,l) | Greywacke | Hill |
|--|--------------------------|-----------------|-----------|------|
| Steep Gley) Step+Gley) | | y | | |
| Steep Pallic, Melanic and Semiarid (Step+EPSa) | | y | | |
| Steep Perched Ultic, Granular, Oxidic (Step+PrchU) | | y | | |
| Steep Perched Other (Step+PrchO) | | y | | |
| Steep Ultic, Granular, Oxidic (Step+GUOx) | | y | | |
| Steep Recent and Raw (Step+RcRw) | | y | | |
| Steep Rocky (Step+Roky) | | y | | |
| Steep Sandy (Step+Sand) | | y | | |
| Perched Ultic, Granular, Oxidic (PrchU) | | y | | |
| Perched Volcanic (PrchV) | | y | | |
| Perched Other (PrchO) | | y | | |
| Pumice (Pumc) | | y | | |
| Allophanic (Allo) | y | y | | |
| Gley (Gley) | y | y | | |
| Brown and Podzol (BrPz) | y | y | y | y |
| Melanic, Pallic and Semiarid (EPSa) | y | y | y | y |
| Granular, Ultic and Oxidic (GUOx) | y | y | | y |
| Recent and Raw (RcRw) | y | y | y | y |

4 Results

The reclassification of the soil properties in the FSL/LRI according to Table 1, resulted in 135 soil groups as shown in Table 2. The set of final soil groups represents the unique combinations of attributes as specified in Table 1 that were found in the FSL/LRI. For example, in the Allophanic group there were no map units with low PAW. Each group was matched to the nearest sibling defined in S-map. The S-map database was filtered so the attributes that defined each FSL group could be segregated within the database and an appropriate sibling that represented the average soil hydraulic features of the class was selected.

Table 2. List of soil groups found in the FSL/LRI and their associated S-map sibling

| Classification | smapsoilname |
|----------------|--------------|
| Allo+h+mo | Otor_24b.1 |
| Allo+h+r | Ngak_26b.1 |
| Allo+h+s | RowH_3a.1 |
| Allo+me+mo | Danvk_31a.1 |
| Allo+me+s | RowH_3a.1 |

| Classification | smapsoilname |
|-----------------------|---------------------|
| Alpn+RcRw+me+NotHill | Mata_11b.1 |
| Brock | Skel_6a.1 |
| BrPz+h+mo+Hill+GW | Glad_80a.1 |
| BrPz+h+mo+Hill+NotGW | Rame_5a.1 |
| BrPz+h+mo+NotHill | Orono_232a.1 |
| BrPz+h+r+Hill+NotGW | Ngong_14a.1 |
| BrPz+h+r+NotHill | Ngong_10a.1 |
| BrPz+h+s+Hill+GW | Renp_1a.1 |
| BrPz+h+s+Hill+NotGW | Wytat_12a.2 |
| BrPz+h+s+NotHill | Moko_19a.1 |
| BrPz+l+mo+Hill+GW | Teng_29a.1 |
| BrPz+l+mo+Hill+NotGW | Glad_126a.1 |
| BrPz+l+mo+NotHill | Mand_21a.1 |
| BrPz+l+r+Hill+NotGW | Fork_2a.1 |
| BrPz+l+r+NotHill | Fork_2a.1 |
| BrPz+l+s+Hill+GW | Bushs_3b.1 |
| BrPz+l+s+Hill+NotGW | Bushs_3b.1 |
| BrPz+l+s+NotHill | Bushs_3b.1 |
| BrPz+me+mo+Hill+GW | Teng_29a.1 |
| BrPz+me+mo+Hill+NotGW | Glad_57a.1 |
| BrPz+me+mo+NotHill | Glad_53a.1 |
| BrPz+me+r+Hill+NotGW | Glad_57a.1 |
| BrPz+me+r+NotHill | Mku_9a.1 |
| BrPz+me+s+Hill | Ihak_21a.1 |
| BrPz+me+s+Hill+GW | Ypori_3a.1 |
| BrPz+me+s+Hill+NotGW | Mokau_2a.1 |
| BrPz+me+s+NotHill | Ihak_21a.1 |
| EPSa+h+mo+Hill+GW | Barr_3a.1 |
| EPSa+h+mo+Hill+NotGW | Fris_1a.1 |
| EPSa+h+mo+NotHill | Barr_1a.1 |
| EPSa+h+r+NotHill | Barr_1a.1 |
| EPSa+h+s+Hill+GW | Tipa_2a.1 |
| EPSa+h+s+Hill+NotGW | Broo_4a.1 |
| EPSa+h+s+NotHill | Paha_46a.1 |
| EPSa+l+mo+Hill+GW | Otem_1a.1 |
| EPSa+l+mo+Hill+NotGW | Otem_1a.1 |
| EPSa+l+mo+NotHill | Culv_8a.1 |
| EPSa+l+r+NotHill | Culv_8a.1 |

| Classification | smapsoilname |
|-----------------------|---------------------|
| EPSa+l+s+Hill+NotGW | Highc_29a.1 |
| EPSa+l+s+NotHill | Lowc_5a.1 |
| EPSa+me+mo+Hill+GW | Otem_3a.1 |
| EPSa+me+mo+Hill+NotGW | Berw_2a.1 |
| EPSa+me+mo+NotHill | Barr_4a.1 |
| EPSa+me+r+Hill+NotGW | Berw_2a.1 |
| EPSa+me+r+NotHill | Otem_3a.1 |
| EPSa+me+s+Hill+NotGW | Henly_1a.1 |
| EPSa+me+s+NotHill | Kelc_9a.1 |
| Estu | NULL |
| FibO | Mngr_8a.1 |
| Fill+l+r | Tail_3a.1 |
| Gley+h+mo | Matpi_4a.1 |
| Gley+h+r | Aran_1a.1 |
| Gley+h+s | Flax_92a.1 |
| Gley+l+mo | Lees_6a.1 |
| Gley+l+r | Aran_17a.1 |
| Gley+l+s | Hume_5a.1 |
| Gley+me+mo | Lums_6a.1 |
| Gley+me+r | Aran_1a.1 |
| Gley+me+s | Wate_13a.1 |
| GUOx+h+mo+Hill | Kaaw_13a.1 |
| GUOx+h+mo+NotHill | Kaaw_13a.1 |
| GUOx+h+s+Hill | Whara_4a.1 |
| GUOx+h+s+NotHill | Fanga_14a.1 |
| GUOx+l+mo+Hill | Kaaw_9a.1 |
| GUOx+l+mo+NotHill | Kaaw_9a.1 |
| GUOx+me+mo+Hill | Morr_15a.1 |
| GUOx+me+mo+NotHill | Morr_15a.1 |
| GUOx+me+s+Hill | Fanga_4a.1 |
| GUOx+me+s+NotHill | Fanga_4a.1 |
| Hydr+l | Waiko_1a.1 |
| Hydr+me | Waiko_1a.1 |
| Ice | NULL |
| Lake | NULL |
| Peat+h | Utuh_11a.1 |
| Peat+l | Andr_16a.1 |
| Peat+me | Utuh_33a.1 |

| Classification | smapsoilname |
|-----------------------|---------------------|
| PrchO+h | Clar_11b.2 |
| PrchO+l | Nald_1a.1 |
| PrchO+me | Clar_2a.4 |
| PrchU+h | Ptiti_3a.1 |
| PrchU+l | Hoki_5a.1 |
| PrchU+me | Otang_3a.1 |
| PrchV+h | Mang_9a.1 |
| Pumc+h | Taup_101a.1 |
| Pumc+l | Frost_2a.1 |
| Pumc+me | Taup_50a.1 |
| quar | NULL |
| RcRw+/+r+NotHill | Mata_11b.1 |
| RcRw+h+mo+Hill+NotGW | Ngah_16a.2 |
| RcRw+h+mo+NotHill | Waim_70a.1 |
| RcRw+h+r+Hill+NotGW | Ngau_2a.1 |
| RcRw+h+r+NotHill | Galt_12a.1 |
| RcRw+h+s+NotHill | Prebb_10a.1 |
| RcRw+l+mo+NotHill | Raka_1a.1 |
| RcRw+l+r+NotHill | Rang_35b.2 |
| RcRw+l+s+Hill+NotGW | Thim_3a.1 |
| RcRw+l+s+NotHill | Thim_3a.1 |
| RcRw+me+mo+NotHill | Waim_40a.2 |
| RcRw+me+r+Hill | Mcqn_10a.1 |
| RcRw+me+r+Hill+NotGW | Taraw_3a.1 |
| RcRw+me+r+NotHill | Waim_4b.1 |
| RcRw+me+s+NotHill | Esk_5a.1 |
| rive | NULL |
| Roky+Hill+NotGW | Mauma_4b.1 |
| Roky+NotHill | Rocky_1a.1 |
| Sali+Gley | Yang_3b.1 |
| Sali+RcRw | Elle_6a.1 |
| Sand+h | Wiku_30a.1 |
| Sand+l | Kyra_1a.1 |
| Sand+me | Wiku_20a.1 |
| Step+Allo+h | Moes_1a.2 |
| Step+Allo+me | Hinga_1a.1 |
| Step+BrPz+h | Matyk_26a.1 |
| Step+BrPz+l | Ruahi_15a.1 |

| Classification | smapsoilname |
|-----------------------|---------------------|
| Step+BrPz+me | Matyk_26a.1 |
| Step+EPSa+h | Poke_1b.1 |
| Step+EPSa+l | Tipa_4b.1 |
| Step+EPSa+me | Henly_1a.1 |
| Step+Gley+h | Invr_13a.1 |
| Step+GUOx+h | Kimp_1b.1 |
| Step+Hydr+me | Waiko_1a.1 |
| Step+PrchO+h | Wehen_17a.1 |
| Step+PrchO+me | Tevi_4a.1 |
| Step+PrchU+h | Puko_3a.1 |
| Step+Pumc+h | Omor_5a.1 |
| Step+Pumc+l | Omor_4a.1 |
| Step+Pumc+me | Omor_4a.1 |
| Step+RcRw+h | Otama_2a.1 |
| Step+RcRw+l | Mata_11b.1 |
| Step+RcRw+me | Mahoe_6a.1 |
| Step+Roky+h | Kario_2b.1 |
| Step+Roky+l | Omrk_8a.1 |
| Step+Roky+me | Kario_2b.1 |
| Step+Sand+l | Pokor_1a.1 |
| Step+Sand+me | Pokor_1a.1 |
| Town | NULL |

The linkage between the classification and the siblings is managed within the S-map database so that the layer can be readily combined with S-map where this is available, and tools such as the ASPIM Library Generator can be used.

5 Discussion and Conclusions

A simple classification based on some of the available FSL/LRI information has been developed. This identifies groups of soils that behave similarly with respect to soil hydraulics. Each group has been linked to a representative sibling from S-map. The FSL/LRI information describes just the dominant sibling in each map unit. The available information is very rudimentary, with high uncertainty.

The polygon linework can be very coarse and may not be a good representation of soil variability. In other words, the representative sibling may not be very representative of the soils found in reality at the location of a FSL/LRI map unit.

6 Recommendations

This approach of mapping the FSL/LRI to S-map should only be viewed as an interim solution. The link to S-map does not solve the accuracy related shortcomings of the FSL/LRI information. New soil surveys are needed to replace the FSL/LRI information.

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