

### Data gap filling

The original dataset has some null values where the land cover data of USGS indicate soil. These null values are filled as described as following.

Except the ice and snow not between the 60°S and 60°N and water, we assume all land cover type need a value of soil properties.

First, the null values are set to zero if the soil property is total carbon, total nitrogen, total sulfur, exchangeable potassium, organic carbon, total phosphorus, or phosphorus measure by five methods (these properties usually decreased a lot with depth). Otherwise, the null values are supplemented by the value of the upper layer except the top soil layer.

Secondly, the null values are filled horizontally. The null values are set to zero if the soil property is in the list above. Otherwise, the null values are set to the mean value within a window. The window size is increased in the following order: 5, 10, 20, 40, 80, 240, 1000 and 5000 pixels. If there is no value within the biggest window, the null values can not be filled and has to be set to a default value if an application needs to assume it as soil. The recommended default value look up table is as following.

Attribute	Default value	units	Scale factor
total carbon	0	% of weight	0.01
organic carbon	0	of weight	0.01
total N	0	% of weight	0.01
total S	0	% of weight	0.01
CaCO <sub>3</sub>	0	% of weight	0.01
gypsum	0	% of weight	0.01
pH(H <sub>2</sub> O)	70		0.1
pH(KCl)	70		0.1
pH(CaCl <sub>2</sub> )	70		0.1
Electrical conductivity	600	ds/m	0.01
Exchangeable calcium	0	cmol/kg	0.01
Exchangeable magnesium	0	cmol/kg	0.01
Exchangeable sodium	0	cmol/kg	0.01
Exchangeable potassium	0	cmol/kg	0.01
Exchangeable aluminum	0	cmol/kg	0.01
Exchangeable acidity	0	cmol/kg	0.01
Cation exchange capacity	0	cmol/kg	0.01
Base saturation	0	%	
Sand content <sup>b</sup>	50	% of weight	
Silt content	30	% of weight	
Clay content	20	% of weight	
Gravel content	0	% of volume	
Bulk density	120	g/cm <sup>3</sup>	0.01

Volumetric water content at -10 kPa	35	% of volume	
Volumetric water content at -33 kPa	30	% of volume	
Volumetric water content at -1500 kPa	10	% of volume	
The amount of phosphorous using the Bray1 method	0	ppm of weight	0.01
The amount of phosphorous by Olsen method	0	ppm of weight	0.01
Phosphorous retention by New Zealand method	0	% of weight	0.01
The amount of water soluble phosphorous	0	ppm of weight	0.00 01
The amount of phosphorous by Mehlich method	0	ppm of weight	0.01
exchangeable sodium percentage	0	% of weight	0.01
Total phosphorus	0	% of weight	0.00 01
Total potassium	0	% of weight	0.01

The dataset is split into tiles to do the above filling, as it is inconvenient to hand it at one time. The whole dataset has 43200 by 16800 pixels. There are 50 tiles and each tile is 4320 by 3360.