# Whroo Flux Tower

# Soil Profile Assessment

*Report for Ian McHugh, Monash University*

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## Background

The Terrestrial Ecosystem Research Network (TERN) SuperSite Network aims to describe baseline characteristics of a range of environmental variables in the hope of establishing trends and adaptations to change (TERN, 2014). This includes the baseline analysis of soil to determine any future changes related to environmental, management or land use changes that may occur in the future (TERN, 2014). The Whroo Flux Tower in Central Victoria is part of the TERN SuperSite Network, and requires a full soil profile with chemical and physical measurements to be undertaken. The soil profile and associated analyses are to use the Australian Standard Methods (Isbell 1996; McDonald et al. 1990; National Committee on Soil and Terrain 2009) with the intention of data to be used as a baseline for further research and monitoring.

This short report describes the profile at the Whroo TERN Super Site, including the standard nomenclature along with physical and chemical analysis of the soil.

## Methods

*Site Description*

The Whroo Flux Tower is located at Latitude -36.673215 and Longitude 145.029247 in Whroo State Park. The average climate statistics for the area is a maximum temperature of 27.9 °C in January and minimum temperature of 3.2 °C in July (Bureau of Meterology, 2015. Station 088109). The yearly average rainfall (recorded over 56 years) is 567.3 mm (Bureau of Meterology, 2015. Station 088109). The general area has a history of gold mining (Cherry, 2004), however there is no visual evidence of past-gold mining activities on the site. The site may have been previously cleared of vegetation for fuel and timber for the nearby gold mining activities, followed by selective harvesting. There is little recruitment of *Eucalyptus* seedlings. The site is now conserved as Whroo State Park, and the vegetation is classed as Dry Schlerophyll Forest with overstorey dominant species being *Eucalyptus microcarpa* (Grey Box). Given the lack of large disturbance, the soil profile should remain in-tact.

Previous regolith analysis of the area, including Whroo State Park, found that the area is largely granite tors with sand, silt, mudstone (Cherry, 2004). The regolith analysis also stated that the soils have poor structure, are clay rich with stone in places, and are nutrient depleted with laterite and/or saprolite layers at approximately 1m depth (Cherry, 2004). There has been no Victorian Government soil survey of the area. Using the Australian Soil Resource Information System (ASRIS), Whroo State Park had two different soils described, one being a Kandosol, and the other a Sodosol (CSIRO, 2013). The Kandosol had two Horizons, with a pH of 4.9 and 5.9, 20% and 40% clay respectively. There was also a plant impeding layer, which suggests the presence of the laterite or saprolite layer. The Sodosol has a pH of 4.7 in topsoil and 5.5 in subsoil, where topsoil is to 0-22.5cm. It was described as being on highly weathered bedrock with red-yellow colours (Dr2.32-Dy3.4). These soil descriptions are for the entire of the Whroo State Park area, and not necessarily of the specific location of the Whroo Flux Tower, which may possess different properties.

*Soil Profile Assessment*

A soil profile was assessed using the Isbell (1996), McDonald et al. (1990) and National Committee on Soil and Terrain (2009) combined approaches, as per the TERN requirements (TERN, 2014). The soil profile was assessed at the Whroo Tower site, approximately 4 meters from the tower on the 25$^{th}$ March 2015. An excavator was used to dig out a pit until bedrock was reached at 160cm, and a 30cm wide strip scraped back to undertake soil assessment (Figure 1). The horizons were then assessed and measured, with a full profile description undertaken using McDonald et al. (1990) and National Committee on Soil and Terrain (2009). One bulk density core was collected at each described horizon using constant volume rings. The soil was very dry and heavy, and collection of bulk density cores caused significant disturbance to the profile. As a result, no other bulk density cores were able to be collected. In addition, 1.5 kg of soil was collected from each horizon for chemical and physical analysis as per the TERN Supersite guidelines.

Soil was analysed for chemical and physical properties at the Environmental Analysis Laboratory (EAL) in Lismore, Australia. All samples were prepared to air dried and < 2mm sieved, and crushed with a ball mill as per method. All samples had the following undertaken using Rayment and Higginson (1992) unless otherwise stated: particle size (Gee and Bauer, 1986); texture (Isbell, 2002); total C (TC) and total N (TN) on a LECO

CNS-2000; acid digest total P (TP) using ICP-MS; electrical conductivity (1:5); ammonium acetate extractable Ca, Mg, K, Na, and KCl extractable Al on an ICP-MS; pH (0.01M $CaCl_2$ and $H_2O$); Colwell-P; trace elements (Cu, Fe, Mn, Zn) using an ICP-MS. Due to the lack of in-tact cores, the suction plate method for volumetric water content was unable to be undertaken. Gravimetric moisture content is reported instead. Bulk density was undertaken at Monash University. As carbonates are not present, total organic carbon (TOC) and total carbon are therefore the same.

**Figure 1 – Whroo Soil Pit, from 0-160cm depth. Photos from Jess Drake (left) with scale, and Ian McHugh (right) with true colours and lighting.**

## Results

The soil profile was broken into three horizons (A1, B1 and B2), and was classed as a Sodosol using the profile description and physical and chemical analysis (Isbell 1996) (Table 1 and 3). The high presence of exchangeable sodium (Table 3) indicates sodicity, where the exchangeable sodium > 6%, and thus its classification is immediately associated with the presence of sodium. A site information table was also filled out using McDonald et al. (1990) and is presented in Table 2. Interestingly, the broader Whroo State Park has evidence of floods and sheet erosion. The location of the pit exactly at the base of the tower, however, does not have evidence of this process.

**Table 1 – Profile description from the Whroo TERN Super Site, as per methods from TERN (2014).**

| **Profile Information** | | **Layer 1** | **2** | **3** | **4** | **5** |
|---|---|---|---|---|---|---|
| ***Horizon*** | | A1 | B1 | B1 | B2 | B2 |
| ***Depth (cm)*** | | 0-7 | 8 to 38 | 39-58 | 59-112 | 113-160 |
| ***Boundary*** | *Distribution* | Clear | Diffuse | Diffuse | Diffuse | Diffuse |
| | *Shape* | Wavy | Irregular | Irregular | Irregular | Irregular |
| ***Colour*** | *Moist matrix* | 7.5YR 4/2 | 10YR 4/3 | 10YR 5/3 | 7.5YR 5/6 | 7.5YR 5/4 |
| | *Dry matrix* | 7.5YR 5/3 | 10YR 5/3 | 10YR 5/4 | 7.5YR 5/6 | 7.5YR 5/4 |
| ***Mottle*** | *Abundance (%)* | 2 to 10 | 10 to 20 | 10 to 20 | 20 to 50 | 10 to 20 |
| | *Size (mm)* | 5 to 15 | 15 to 30 | >30 | >30 | 5 to 15 |
| | *Contrast* | Faint | Distinct | Distinct | Distinct | Faint |
| | *Primary Mottle* | 5YR 6/8 | 5YR 5/8 | 5YR 6/6 | 2.5YR 5/8 | 2.5YR 5/6 |
| | *Colour* | Yellow | Yellow | Yellow | Red-Orange | Red-Orange |
| | *Boundary* | Diffuse | Clear | Clear | Clear | Diffuse |
| ***Stickiness*** | | Slightly | Slightly | Very | Very | Very |
| ***Plasticity*** | *Degree* | Normal | Normal | Normal | Normal | Normal |
| | *Type* | Slightly | Very | Very | Very | Very |
| ***Carbonates*** | | None | None | None | None | None |
| ***Gypsum*** | | None | None | None | None | None |
| ***Coarse*** | *Abundance (%)* | 2 to 10 | None | None | None | None |
| ***Fragments*** | *Size (mm)* | 2 to 6 | None | None | None | None |
| | *Shape* | Subrounded | None | None | None | None |
| | *Lithology* | Other/ Ironstone | None | None | None | None |
| | *Distribution* | Dispersed | None | None | None | None |
| ***Roots*** | *Size (mm)* | 1 to 2 | 1 to 2 | 1 to 2 | >5 | >5 |
| | *Abundance* | Common | Few | Few | Few | Few |
| ***pH (field)*** | | 5 | 5.5 | 6.5 | 6.5 | 6.5 |
| ***Effervescence*** | | None | None | None | None | None |
| ***Cutans (field)*** | | None | None | None | None | None |
| ***Pores*** | *Diameter of macropores (mm)* | 2 to 5 | 1 to 2 | 1 to 2 | 1 to 2 | 1 to 2 |
| | *Quantity Macro >2mm* | Many | Few | Few | None | None |
| | *Quantity Macro <2mm* | Many | Common | Common | Few | Few |
| ***Structure*** | *Grade* | Moderate | Moderate | Moderate | Massive | Massive |
| | *Size (mm)* | <2 | <2 | 2 – 5 | | |
| | *Type* | Subangular blocky | Subangular blocky | Subangular blocky | Massive | Massive |
| ***Texture*** | | Silty clay loam | Light clay | Light clay | Light clay | Light clay |
| ***Consistency*** | | Very strong | Very strong | Very strong | Very strong | Very strong |
| ***Pans*** | | None | None | None | None | None |
| ***Fabric*** | | Rough-ped | Rough-ped | Rough-ped | Rough-ped | Rough-pe |
| ***Voids (mm)*** | | <10 | <5 | <5 | <5 | <5 |

**Table 2 – Site description information from the Whroo TERN SuperSite, as per methods of McDonald et al. (1990).**

| Information Type | Site Descriptor | Assessment Outcome |
|---|---|---|
| ***General*** | *Latitude and Longitude* | -36.673215, 145.029247 |
| | *State* | Victoria, Australia |
| | *Locality* | Whroo State Park |
| | *Surveyor* | Dr Jess Drake, Monash University |
| | *Date of Survey* | 25th March 2015 |
| ***Landform*** | *Slope Class* | Very gently inclined |
| | *Morphological Type* | Flat |
| | *Element* | Plain |
| | *Relief (m)* | <9 |
| | *Relief/Modal Terrain Class* | Gently undulating plain |
| | *Pattern* | Plain |
| ***Slope*** | *Evaluation method* | Estimate |
| | *Value (%)* | <2 |
| ***Elevation*** | *Evaluation method* | Cherry, 2004 |
| | *Value (m)* | 110-210 |
| ***Aspect*** | | East South East |
| ***Depth to Free Water (m)*** | | 0 |
| ***Runoff*** | | Moderately rapid to rapid |
| ***Permeability*** | | Slowly permeable (5-50 mm/day) |
| ***Drainage height (m)*** | | 0 |
| ***Inundation*** | | None |
| ***Rainfall*** | | 500-600 mm |
| ***Soil or Land Class*** | | Kandosol or Sodosol (ASRIS) |
| ***Great Soil Group (USDA)*** | | Solodic soil |
| ***PPF (Northcote)*** | | Uf1.43 |
| ***Soil Taxonomy (Isbell)*** | | Sodosol |
| ***Vegetation*** | *Type* | Tree |
| | *Tallest Form* | Tree, open forest, 20-35m tall |
| | *Tallest Dominant Species* | *Eucalyptus microcarpa* (Grey box) |
| | *Mid Form* | Shrub, sparse, 1-3m tall |
| | *Mid Dominant Species* | *Cassina arculeata* (Dogwood) and *Acacia acinacea* (Gold Dust Wattle) |
| | *Ground Stratum* | Not present |
| ***Aggradation*** | | Not apparent |
| ***Erosion*** | *Type* | None present, Stable |
| | *Degree* | None present, Stable |
| ***Disturbance*** | | Site has previously undergone historical Extensive Clearing. Regrowth present. |
| ***Mircorelief*** | *Agent* | None |
| | *Type* | None present |
| ***Surface Coarse Fragments*** | *Abundance (%)* | 20-50 |
| | *Size (mm)* | 01/06/20 |
| | *Shape* | Subrounded |
| | *Lithology* | Ironstone (not pedogenic origin) |
| ***Rock Outcrop*** | *Abundance (%)* | 0 |
| ***Condition Surface Soil*** | | Hard setting |
| ***Depth to Pan/Substrate (cm)*** | | 160 |
| ***Substrate Material*** | *Type of observation* | Literature (Cherry, 2004) |
| | *Confidence* | Dubious, doubtful |
| | *Depth from surface (cm)* | 160-500 |
| | *Porosity* | Slightly porous |
| | *Strength (MPa)* | 100-200 |
| | *Alteration* | Other |
| | *Lithology* | Granite, Sand and Silt Mudstone, Conglomorate. |
| | *Coarse Material* | N/A |
| | *Gen Type* | Igneous, Metamorphic, Sedimentary |
| ***Detail Site Information*** | | Flat site, dry schllerophyll forest. Some minor gold mining disturbance through forest harvesting and fire. |

**Table 3 – Soil chemical and physical parameters from Whroo TERN SuperSite.**

| Soil Property | Layer 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| ***EC dS/m*** | 0.28 | 0.22 | 0.86 | 0.29 | 0.25 |
| ***pH ($H_2O$)*** | 6.19 | 6.88 | 7.15 | 7.92 | 7.73 |
| ***pH ($CaCl_2$)*** | 5.21 | 5.82 | 6.52 | 6.66 | 6.59 |
| ***GMC %*** | 2.9 | 5 | 4.9 | 5.1 | 4.7 |
| ***BD g/cm$^3$*** | 1.2 | 1.5 | 1.8 | 1.9 | 1.9 |
| ***Gravel > 2mm*** | 0 | 0 | 0 | 0 | 0 |
| ***Sand >50µm*** | 36.3 | 23.2 | 23.5 | 19 | 23.2 |
| ***Sand >20µm*** | 57.7 | 39.5 | 36.1 | 36.9 | 40.3 |
| ***Silt 2- 50µm*** | 45 | 34.2 | 34.8 | 34.8 | 34.7 |
| ***Silt 2-20µm*** | 23.6 | 18 | 22.2 | 16.9 | 17.5 |
| ***Clay <2µm*** | 18.7 | 42.5 | 41.7 | 46.2 | 42.1 |
| ***Texture*** | Medium Clay | Medium Clay | Medium Clay | Medium Clay | Medium Clay |
| ***TC %*** | 1.5 | 0.71 | 0.4 | 0.21 | 0.06 |
| ***TN %*** | 0.08 | 0.05 | 0.04 | 0.04 | 0.03 |
| ***TP mg/kg*** | 105 | 65 | <50 | <50 | <50 |
| ***Ex. Ca meq/100g*** | 2.01 | 0.93 | 0.49 | 0.22 | 0.1 |
| ***Ex. Na meq/100g*** | 2.13 | 4.2 | 7.04 | 7.6 | 7.22 |
| ***Ex. K meq/100g*** | 1.07 | 1.23 | 1.29 | 1.1 | 0.95 |
| ***Ex. Mg meq/100g*** | 8.46 | 11.79 | 14.16 | 14.77 | 13.18 |
| ***Al meq/100g*** | 0.02 | ..01 | 0.01 | 0.01 | 0.01 |
| ***Ex. Na %*** | 15.5 | 23.1 | 30.6 | 32.1 | 33.7 |
| ***Colwell-P mg/kg*** | 7 | 4 | 2 | 2 | 2 |
| ***Cu mg/kg*** | 0.5 | 0.5 | 0.4 | 0.3 | 0.4 |
| ***Fe mg/kg*** | 223 | 97 | 45 | 34 | 47 |
| ***Mn mg/kg*** | 5 | 4 | 4 | 2 | <1 |
| ***Zn mg/kg*** | 0.7 | 0.3 | 0.2 | 0.1 | 0.4 |

## Discussion and Conclusion

The soil at the Whroo Flux Tower TERN SuperSite is classified as a Sodosol (Isbell, 1996). It has typical characteristics of a Sodosol, including exchangeable sodium > 6%, poor drainage as featured by the high degree of mottling, poor structure, low fertility (Table 3) and poor aeration (as pores) and low root mass. The suborder of the Sodosol is Yellow (AC), its Great Group is Mottled-Mesonatric (FO) (Isbell, 1996). The classification of the soil as a Sodosol is also consistent with the ASRIS survey of the area, which also found Sodosols present (CSIRO, 2013) in Whroo State Park.

Given the highly sodic nature of the soil, the site will have particular features which will not change over time, provided that land management also does not change. Sodic soils have weak structure and tend to be massive due to the repellence between sodium ions. This means that there is also poor porosity which affects soil air and water access by plant roots (Curtin and Naidu, 1998; Rengasamy, 2006). Highly sodic soils also usually occur in combination with poor fertility and lack of plant access to nutrients (Curtin and Naidu, 1998; Rengasamy, 2006). Combined, this causes poor root growth, and reduced shoot growth (Curtin and Naidu, 1998; Rengasamy, 2006). Therefore, vegetation on sodic soils is often limited by species with sufficient adaptation to the conditions (Marcar and Crawford, 2004).

If the site was altered for forestry or other agricultural productive purposes, only plant species with adaptations to waterlogging, poor nutrient availability and poorly structured soils will do well. There have been cases where organic amendments have improved these soils (Drake et al. 2015; Hulugalle et al. 2010; Wong et al. 2009), but studies are limited and are often in locations where production agriculture is already occurring or where sodicity may have been induced due to management. In this case, sodicity is natural and maintaining the forest cover will minimise risk of erosion and loss to productivity. If forestry practices are undertaken on site, site establishment of species will be slow and difficult given the soils properties. The best management for this site would be as conservation and a long-term carbon bank.

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