TERN data for students

A summary of ecosystem monitoring methods, data and activity ideas for advanced students and teachers.

TERN Ecosystem Surveillance
April 2020

The content of this document has relevance to Australian Curriculum Year 11 and Year 12 Biology: Biodiversity and the Interconnectedness of Life

tern
Ecosystem Research Infrastructure

NCRIS
National Research
Infrastructure for Australia
An Australian Government Initiative

Acknowledgements

Citation

TERN (2020). *TERN data for students: a summary of ecosystem monitoring methods, data and activity ideas for advanced students and teachers. Relevant to the Australian Curriculum Year 11 and Year 12 Biology*. TERN, Adelaide (tern.org.au).

For more information

TERN provides researchers with access to spatio-temporal field and sensor data representing key attributes of Australia's terrestrial ecosystems. The data are gathered with the use of survey tools, satellite and drone remote sensing and sensors such as those for soil moisture, acoustics, flux and phenology. Related soil and vegetation samples are also collected by TERN for researcher use.

For more information on TERN, visit tern.org.au

More detailed information on the TERN Ecosystem Surveillance methods discussed in this document can be found in the TERN AusPlots Rangelands Protocols Manual (White *et al.* 2012), available from the TERN website.

For more information regarding this document, please contact Ben Sparrow, Associate Professor and Program Lead, TERN Ecosystem Surveillance: phone 08 8313 1201 or email ben.sparrow@adelaide.edu.au

Contents

Introduction

Understanding and addressing the grand challenges facing our environment, such as climate change, drought and loss of biodiversity, requires analysis of *big data.*

Big data on the environment is collected via multiple methods. Satellite and drones are being used more and more, but they still rely on field data to ensure their accuracy. Contemporary, broad-scale ecosystem field surveys provide valuable data on the environment and how it is changing over time.

TERN is Australia's land ecosystem observatory. It measures key terrestrial ecosystem attributes over time from continental scale to field sites at hundreds of representative locations and openly provides model-ready data. TERN's Ecosystem Surveillance platform collects detailed soil and vegetation data across a national network of over 700 plots.

The data and samples collected by TERN are made openly available to researchers who use them alongside other data to to detect and interpret changes in land ecosystems and, in turn, inform policy and management.

This document enables teachers and students to access this large set of TERN ecosystem data. It provides an alternative to teachers and students collecting their own field data for educational activities.

The document provides information and explanation to help you get started using TERN datasets. It can be used to help gain an insight into scientist-collected data, and aid in analysis and understanding of *big data*, *open-source data*, field methods, statistics, and habitat variables.

For simplicity, we recommend students use the attached spreadsheet 'TERN_Data' with this document.

Do you have teaching materials you have developed using TERN data or resources? We would love to help you share them with other instructors interested in using TERN data. Please contact us so that we can help you promote the materials you have created.

Ideas for how to work with the TERN data

Below is a list of ideas and suggestions on how students can utilise the available TERN data. Please contact us if you would like assistance. Please also check the TERN AusPlots website www.ausplots.org/teacher-resources for any additional ideas we may add from time to time.

- Relationships between soil and vegetation. This could be done at the species level – *Enneapogon* grass species for example show a very strong relationship between species and soil PH. You could also do this at a community level - Eucalypt woodlands versus Acacia shrublands or grasslands. For example: Why are the plains around Longreach and Winton in Queensland so devoid of trees? The data sheet contains a list of the major vegetation group that each plot falls into. You can learn a little bit about each of these communities and how they are described here: https://www.environment.gov.au/land/publications/nvis-fact-sheet-series-4-2

- Similarly, there is a relationship between temperature and rainfall and species composition. As an example, there is a notable change in grass species composition in the grassland plots stretching

from Normanton to Longreach (we are using a few Queensland examples here but there are many others across Australia). Using this example, you would see that the same set of grass species is present across this gradient. Looking at the cover of each of these species however and looking at the rainfall data at the same time you will see a marked pattern of change in the dominant species at each plot across the gradient.

- Woody biomass is also strongly correlated to rainfall and you can potentially use the basal area data to show this. Similar to the composition data described above you should be able to link the basal area data at each site with the rainfall data from each site and then compare this across sites that are spread out over a large area. Sometimes these effects will occur over a very short area-crossing into the rain shadow on the Great Dividing Range for example while at other times the change may occur over a much larger area

- Introduced plant species as presence/absence, i.e. how many plots have introduced species vs how many do not,and is there a pattern in this. Or in terms of cover, how much of the biomass of a plot is made up of introduced species? Is this correlated to climate, soil, land use, proximity to population centres, states, regions etc. Many of these introduced species will be familiar to students as they are garden/horticultural/agricultural escapees. There could be some further questions here around how those species may have gotten into the plots and what impact they may be have on the native vegetation and wildlife Information on a species status as native or introduced is contained in both the plant list and the point intercept data.

- You could also look at threatened species, the plant list contains a list of threatened species from each state as well as those listed nationally. What might the threats to these species be? Often the states have developed recovery plans for these species that may list the threats but there may be others. Are the TERN plots they are collected in protected in some way? Are there common threats to these species and are there any links in terms of where these species might occur in the landscape or their growth habits that make them more vulnerable?

- For students interested in GIS, they could look at fire and how often our plots have been burnt before and after our visits. Again there would be some interesting analysis here around climate as well, particularly in relation to seasonality of rainfall. Seasonality is not included in the available 'TERN_AusPlots Data' spreadsheet data but if this is something you want to pursue please contact us. Fire history data in various forms can be accessed from the following sources:

  – WA Fire scar vector data: https://catalogue.data.wa.gov.au/dataset/dbca-fire-history
  – SA fire scar vector data: https://data.sa.gov.au/data/dataset/fire-history
  – NT and northern Queensland can be access through NAFI: https://www.firenorth.org.au/nafi3/ (Tip: search for the fire history section rather than the hotspots)
  – Rest of Queensland has yearly fire scar mapping: https://www.qld.gov.au/environment/land/management/mapping/statewide-monitoring/firescar/firescar-maps

Resources

Field Protocols Manual

The TERN Ecosystem Surveillance manual, titled *AusPlots Rangelands Survey Protocols Manual* (White *et al.* 2012) describes the entire TERN Ecosystem Surveillance process from plot selection and data collection through to curation and publishing of data. The manual can be downloaded from the TERN website https://www.tern.org.au/field-survey-protocols-apps/.

Whilst the information presented in this document focusses on our 'rangelands' manual, please be aware that the method is applicable to use in other biomes of Australia, and is not limited to the rangelands. (The next update of the manual will be re-titled to reflect this). Another manual, titled the *AusPlots Forests Survey Protocols Manual* (Wood *et al.* 2014), describes the background, methods and techniques of the TERN 'forests' method. The forests manual can also be downloaded from the TERN website https://www.tern.org.au/field-survey-protocols-apps/. We have not included information from our forests program in this document, however please contact us if you would like information on how the forests program could be incorporated into your curriculum.

Plot map

A map of all 700+ TERN Ecosystem Surveillance plots is presented in Figure 1, and can also be found on the TERN website https://www.tern.org.au/tern-observatory/tern-ecosystem-surveillance/. An interactive map can be found here https://www.tern.org.au/tern-observatory/

Figure 1. TERN Ecosystem Surveillance plot network

Summary reports

We have available a range of reports which summarise plot descriptions and data in various geographic locations, or on large scale gradients. Please contact us for a summary document for your area of interest, whether it is a defined geographic area or large scale transect/environmental gradient. Example reports are available on the AusPlots website http://www.ausplots.org/science-outputs#Property. (The AusPlots website is currently active but will be archived in late 2020 as information is moved to the parent TERN website.)

Available data types

Point intercept data

The point intercept method is a straightforward method that is readily repeatable and requires little instruction to produce reliable plot information. It provides accurate benchmark data at each plot including substrate type and cover. It also provides species structural information such as growth form, height, cover and abundance and population vertical structure. The demographic information produced at each plot can be compared spatially to indicate plot differences, and temporally to indicate change over time. Additionally, the cover data collected at each plot can be used to validate cover data extrapolated through remote sensing techniques.

Plant collections

Each species that is found within the plot has a herbarium grade sample taken. These have all been formally identified by the relevant state/territory herbaria for which the sample was collected, i.e. the State Herbarium of South Australia, or in some instances the Australian National Herbarium. Once identified, much of the material is then lodged at the relevant herbarium, or alternatively, at the Adelaide node of TERN.

Leaf tissue samples

For all plant specimens collected, a leaf tissue sample is also taken. This involves placing leaf samples from each species into a cloth bag and drying them on silica desiccant. All of the dominant species have an extra four samples collected. These samples are available for use on application to TERN. They are able to be used for genetic analysis, isotopic composition and range of other uses.

Plot description information

Contextual information is also collected at each plot. This includes measures of slope and aspect, surface strew and lithology, and information on the grazing and fire history of the plot. The plot's location is also recorded with a differential GPS and the plot corners and centres (with landholder permission) are marked with a star picket.

Structural summary

Detailed structural summary information is collected at each plot. When combined with the height and cover information from the point intercept data it enables the creation of a structural description compatible with the National Vegetation Information System (NVIS) level 5 description. More information on NVIS can be found on the Department of Agriculture, Water and the Environment website https://www.environment.gov.au/land/native-vegetation/national-vegetation-information-system.

Leaf Area Index

In plots where a mid and/or upper canopy is present, a measure of leaf area is recorded. The tool used is an LAI2200 and it captures LAI measurements in a range of canopies using one or two sensors attached to a single data logger (LI-COR 1990). The LAI data has a range of potential applications, such as studies of canopy growth, canopy productivity, woodland vigour, canopy fuel load, air pollution deposition, modelling insect defoliation, remote sensing, and the global carbon cycle.

Basal area

Basal area measurements are collected across plots where woody biomass is taller than 2 m. Basal area measurements provide information useful for calculating biomass and carbon levels and for structural studies. The wedge aperture, the length of string – 50 cm (and hence the distance from the eye and subsequent angle from the eye to the edges of the wedge aperture) and species count are all important in calculations. Algorithms developed for use with the basal wedge include the above data to calculate plant basal area on a per hectare basis even though species are counted outside the one-hectare plot area. The method is plotless but used because it is based on the concept of circles (trunks/basal area) within circles (circular plots) – the area of one varies proportionally to the change in the area of the other. Use of the basal wedge may be superseded by further improvement of the 3D photo point method and development of algorithms to provide information on vegetation community structure.

Soil classification

Description of soils, including basic information on the observations that has been recorded, the number of recordings and the coverage of locations, are generally poor across the rangelands region of Australia. The plot descriptions and soil characterisations collected using the AusPlots method will substantially alleviate this paucity of information. The data collected can also be used to increase the reliability of the rangelands component of the Soil and Landscape Grid of Australia, produced by TERN consistent with the Global Soil Map specifications. Analyses of the collected soil samples will greatly enhance the level of knowledge (e.g. nutrient and carbon levels) and hence understanding of rangelands soils and how they will respond to climate change and management options. Eventually we, with our collaborators, hope to be able to analyse all nine of the soil pit samples from within the plot using a number of different methods e.g. wet chemistry, MIR (mid infrared spectrometry) or NIR (near infrared spectroscopy), either individually to provide a measure of variation of the parameter being measured across a plot or bulked together and a sub-sample extracted and analysed to provide a mean value for that parameter across a plot.

Soil meta barcoding samples

Metagenomics is the study of genetic material recovered directly from environmental samples. Soil metagenomics provides the opportunity to understand what organisms are present at survey plots and

provides an indication of their abundance. The collection techniques result in a bias towards higher order organisms.

Soil bulk density

Soil bulk density (BD), also known as dry bulk density, is the weight of dry soil divided by the total soil volume. The total soil volume is the combined volume of solids and pores which may contain air or water, or both. The average values of air, water and solids in the sample are easily measured and are a useful indication of a soil's physical condition. Soil test results are most often presented either as a percentage of soil (e.g. % organic carbon) or as a weight per unit of soil (e.g. nitrogen, mg/kg). As bulk density is a measure of soil weight in a given volume, it provides a useful conversion from these units to an area basis unit (e.g. t/ha). The resulting number gives an easily understandable idea of the carbon storage or nutritional status of the soil on an area basis.

3D photo panorama

The TERN Ecosystem Surveillance field method uses a three-dimensional method for photographing the plot. This involves taking three 360-degree panoramas in a triangular pattern. This allows for the creation of a 3D model of the vegetation within the plot which can be used to monitor change over time, track plot condition as well as providing a unique, fast measurement of basal area and biomass.

TERN Data spreadsheet

Please refer to the 'TERN_ Data' spreadsheet. An explanation of the separate sheets for the different data types is provided below.

Tip: The spreadsheet will be updated from time to time. Please contact us to ensure you are working with the most recent version. The spreadsheet is also be available on the AusPlots website www.ausplots.org/teacher-resources.

Plot description information

The *plot description information* sheet helps put the plots in context, including plot location name (the plot code using a unique numbering system), established date, property, bioregion description, description, landform element, landform pattern, plot slope, plot aspect, plot dimensions, comments, surface lithology, latitude and longitude. From this information you may want to whittle plots down to a selected area or compare across particular landforms. All of our plots are 1 ha and are usually 100 m x 100 m. A few plots, usually those on sand dunes, are 50 m x 200 m.

Climate data

The *Climate Data* sheet shows a range of climate information for each plot. Mean annual temperature, mean annual precipitation and elevation are probably the three easiest variables to begin with. The climate data was collated by CSIRO and can be referenced:

> Xu, T., and Hutchinson, M. (2011) ANUCLIM Version 6.1. Fenner School of Environment and Society, Australian National University. Canberra, Australia.

Soil characteristics

The *soil characteristics* contains a subset of the soil information we collect. Soil pH, electrical conductivity (EC) and texture are all strongly correlated with changes in vegetation cover but are in turn affected by rainfall and temperature. Some plots may only have minimal data collected - usually because the plot was difficult to dig or we did not have a soil scientist available to conduct the more detailed analysis.

Basal area

The *basal area* data are a coarse but effective way of measuring diameter at chest height of trees and taller shrubs in a plot. This measure is often calculated through to woody biomass using allometric equations and in turn can be used to look at carbon storage and a range of other ecological measures. It is recorded at 9 points along the edge and at the centre of the plot.

Point intercept data

The *point intercept data* sheet contains information on the cover of species across the plot. The simplest way to calculate cover is to divide the number of point intercept hits by the total points per plot and then multiply by 100. As an example, the first record (line 2), *Eucalyptus dealbata*, would have 21.9% cover. For larger trees we also record the amount of space between the canopy that is not vegetation - this is the 'in canopy sky' value. We also record whether it is dead or alive. You could also aggregate by growth form to work out what percentage of the plot is taken up by each stratum. Tip: take care when summing these figures as many of the plots have more than one visit.

Structural summary

Structural summary takes the cover and height information for each species and stratum and turns that into a structural description for the plot. These are a modified version of an NVIS description, the details of which can be found here

http://www.environment.gov.au/land/native-vegetation/national-vegetation-information-system/data-products

Soil bulk density

The soil *bulk density* is again fairly self-explanatory, see above for in depth explanation. There are plots where bulk density data were not collected due to the plot being too rocky and the rings could not be used. Put simply, bulk density is the ratio of weight to volume to convert other soil measures to volumetric measures.

Plant list

The *plant list* is the species list for each visit, including family, genus, species and vernacular names. It also includes information on whether the species is native or not, the default growth form and the conservation status of each species according to state and federal threatened flora categories.

NVIS major vegetation groups

The National Vegetation Information System (NVIS) is a comprehensive data system that provides information on the extent and distribution of vegetation types in Australian landscapes. The NVIS has been developed and maintained by all Australian governments to provide a national picture that captures and explains the broad diversity of our native vegetation which have been classified into Major Vegetation Groups (MVGs). On the spreadsheet, we provide NVIS version 4.1 MVG categories, MVG name and a description for each of the 861 plots listed.

https://www.environment.gov.au/land/native-vegetation/national-vegetation-information-system.

Stitched panoramas

TERN is in the process of making stitched panoramas available via Cloudstore (similar to Dropbox), but in the meantime, images are available via Dropbox:

https://www.dropbox.com/sh/8bl1ui3mznued47/AADCG-v6ytkJVXcopN2QPsGLa?dl=0

Accessing the data (advanced)

- The R-package developed by the TERN Ecosystem Surveillance team provides up-to-date data if you have the statistical capability https://github.com/ternaustralia/ausplotsR

- Data can also be viewed on the Soils to Satellites website, which contains a range of useful visualisations sourced from the Atlas of Living Australia at http://www.soils2satellites.org.au/. (*please note: Soils to Satellites has not been updated recently, however the project has some useful visualisations of TERN data and is worth investigating. You will need to create a logon.

- Please let us know if you would like access to the TERN Ecosystem Surveillance plots Google Earth file (.kmz). It is a great way to visualise all of the plot locations the plots (except where we are still waiting on plant identifications to come back from that plot). You can view the TERN Ecosystem Surveillance plots on Google maps www.ausplots.org/teacher-resources.

References

White A., Sparrow B., Leitch E., Foulkes J., Flitton R., Lowe A.J. and Caddy-Retalic S. (2012) Ausplots Rangelands Survey Protocols Manual. The University of Adelaide Press.

Wood S., Stephens H., Foulkes J., Bowman D. (2014) AusPlots Forests Survey Protocols Manual. Version 1.6. University of Tasmania.

Xu, T., and Hutchinson, M. (2011) ANUCLIM Version 6.1. Fenner School of Environment and Society, Australian National University. Canberra, Australia

We at TERN acknowledge the traditional owners and their custodianship of the lands on which TERN operates. We pay our respects to their ancestors and their descendants, who continue cultural and spiritual connections to country.

TERN is enabled by NCRIS. Our work is a result of collaborative partnerships with many universities and institutions.

To find out more please go to **tern.org.au**

tern
Ecosystem Research Infrastructure

NCRIS
National Research
Infrastructure for Australia
An Australian Government Initiative