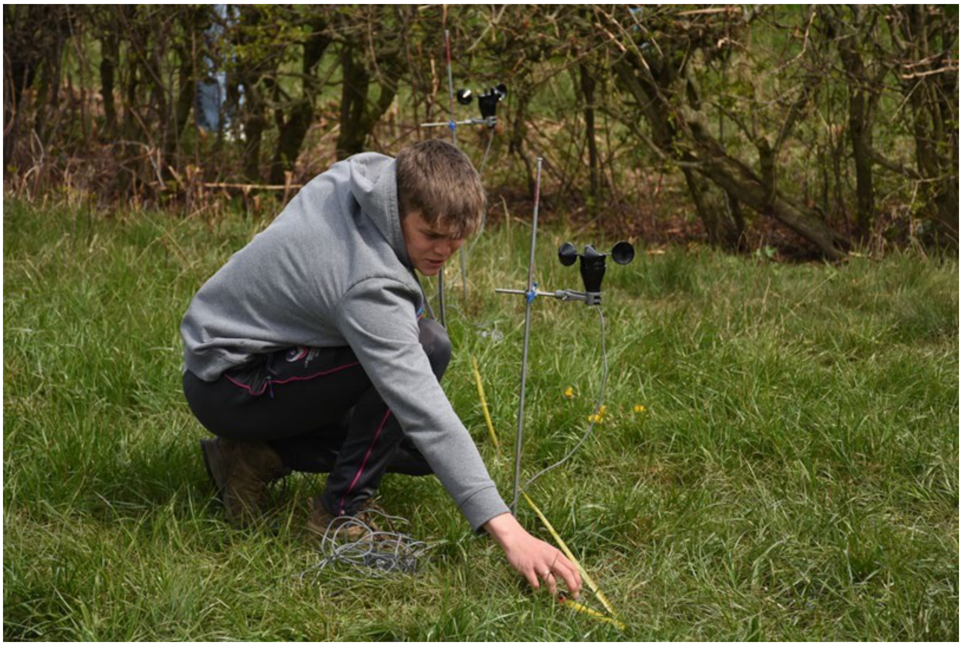

HIIT


Rab



Appendix 1: Forest Ecology

Burleigh Woods field visit, 24th April 2021

20GYB308: Forest Ecology

Aims

- Understand the forest context.
- Gain an overview of Burleigh woods.
- Collect data and samples for measuring carbon stored in:
    - Living biomass
    - Deadwood
    - Soils

Burleigh Woods

Burleigh Woods is approximately 8.5 hectares in size and is owned by Loughborough University (since 2003). The woodland is listed on the Leicestershire Inventory of Ancient Woodlands, recognising that the site has had continuous wooded cover since at least 1600 AD. The species composition is semi-natural and predominantly *Fraxinus excelsior* (Common ash), in the western section and *Quercus petrea* (Sessile Oak) and *Betula pendula* (Silver birch) in the eastern section. The understory consists of coppiced *Corylus avellana* (hazel) and *Ilex aquifolium* (Holly). The woodland contains large aeras of bluebells. The ash were previously coppiced and timber extraction occurred during WWi and WWII.

Safe System of working

A full safety briefing will be provided before the trip. Key points are below.

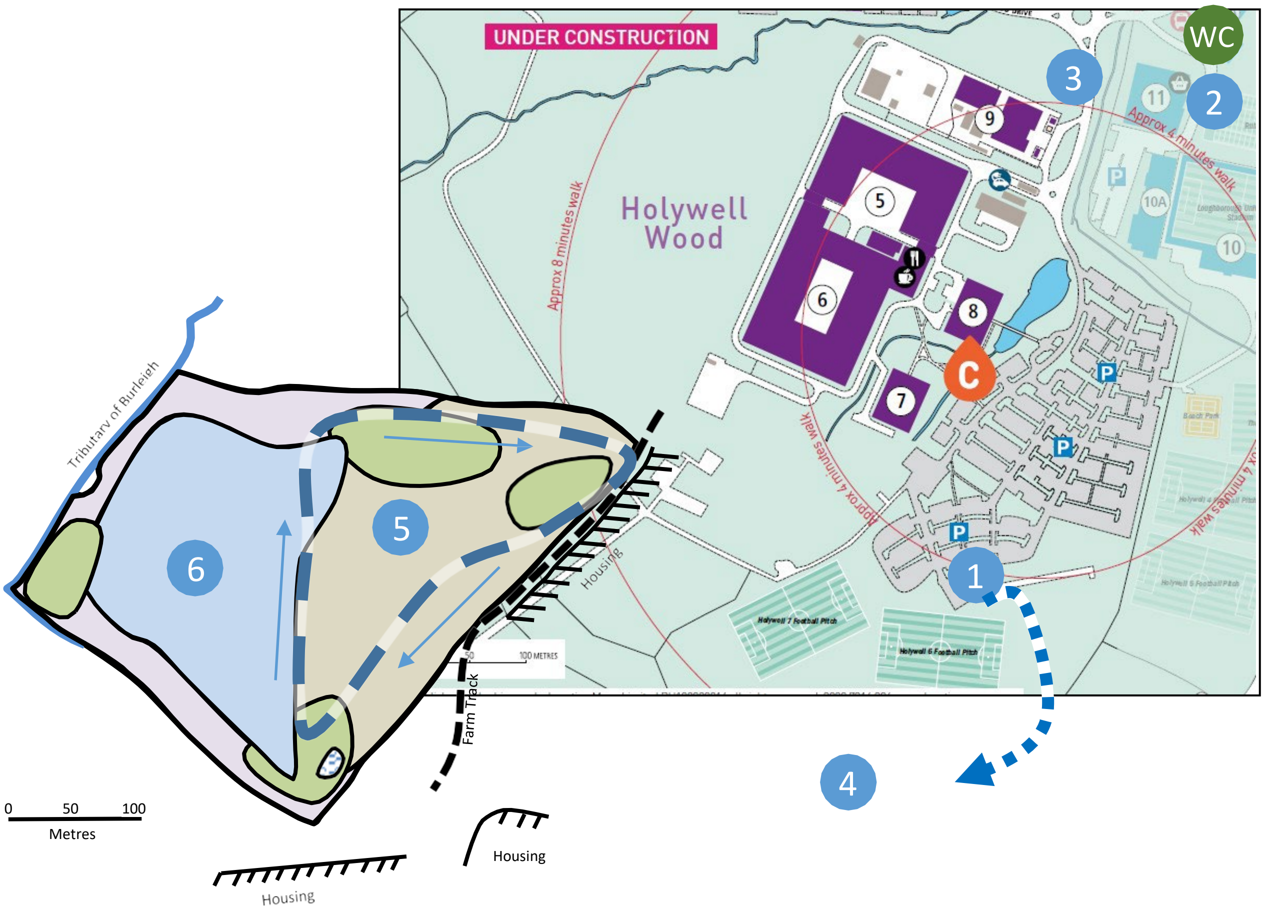
COVID

We must all follow and be seen to follow COVID-safe practices. Students should have recorded a negative lateral flow COVID-19 test result in the 24 hours before the trip. Regardless of this, students exhibiting any COVID-19 symptoms (persistent new cough, loss of smell/taste, fever) should not attend the field trip. Maintain good hand hygiene.

GENERAL

Bring appropriate clothing for the weather. Bring warm clothes and waterproofs. Wear appropriate footwear for rough, muddy ground. Bring adequate drinking water. The closest toilet facilities are in StemLab.

Field day schedule



1	Meet here at either 09.00 or 10.00 (depending on your allocated group)
2	Nearest toilet facilities are in STEMlab
3	Nearest campus bus stop (end of the line)
4	Burleigh woods is approx. here – see enlarged map
5	Oak and Birch
6	Ash

Schedule

Introduction

In this survey you will make measurements of three components of the forest system, to be used to calculate the amount of carbon stored in those components.

After we have walked around the woods, to help you get your bearings, you will work in small groups. You should make the three sets of measurements (above-ground biomass, deadwood, soil) in each of four plots. These should be located within two 'strata' – two plots in the Oak dominated area, and two plots in the ash dominated aera. Work in one plot at a time, and collect all data from that plot before you move on to the next. You will have a total of approx.. 4 hours for data collection, so approx.. 1 hour per plot (though you will be faster on the later plots).

Full guidance on what you need to measure is in the following guides. Please read through these carefully. In brief:

Biomass

1. Within each plot, measure and record by species the dbh of every living tree where this is 7 centimetres or greater.
2. Identify the two trees of each species nearest to the plot centre; these will be your height sample trees. Where a species constitutes less than 10% of the total tree numbers, this should be treated as a "minor species" and grouped with the most similar alternative present in the woodland (see Appendix 3).
3. Measure and record dbh and timber height of the two height sample trees of each species."
4. In addition you will count and measure the height of seedlings and saplings in your plots.

Deadwood

1. Set out a triangular 90 m transect
2. Measure coarse woody debris crossing this transect.
3. Mesaure fine woody debris crossing a sub section of this transect.

Soil

You will simply collect soil samples from your plot.

20GYB08: Forest Ecology

Survey 1: carbon stored in biomass

Introduction

In this survey you will make measurements which you will later use to drive a value for the amount of carbon stored in the tree biomass in Burleigh Woods. These instructions follow closely the 'Carbon Assessment Protocol' produced by the UK Forestry Commission. They are based on an assumption that we can make basic measurements and that these can then be precisely converted into a value for the volume, biomass and then carbon contained in the trees in the woodland. You might want to consider any inaccuracies inherent in this type of approach.

You will be using a 'plot-based survey' because Burleigh Woods is a small forest. The application of the approach involves defining the area of land relevant to the exercise and the breakdown of this land area into homogenous stands. Survey sample plots are put into each stand at random locations and basic measurements are made, typically:

- All trees are counted and classified for species and possibly characteristics such as competitive status and canopy position.
- All of the trees in the plot are measured for dbh.
- A smaller systematic sample of the trees in the plot are measured for total height.

Specifically, you will use 'Method B' in the Carbon Assessment Protocol. This is the method which is the default method for broadleaved stands. It is not the most accurate method, but provides a balance of efficiency and accuracy.

5. Within each plot, measure and record by species the dbh of every living tree where this is 7 centimetres or greater.
6. Identify the two trees of each species nearest to the plot centre; these will be your height sample trees. Where a species constitutes less than 10% of the total tree numbers, this should be treated as a "minor species" and grouped with the most similar alternative present in the woodland (see Appendix 3).
7. Measure and record dbh and timber height of the two height sample trees of each species."
8. In addition you will count and measure the height of seedlings and saplings in your plots.

Further Reading

Jenkins, TAR et al. 2018. FC Woodland Carbon code: Carbon Assessment Protocol. Forestry Commission.

Thompson, DA & Matthews, RW. 1989. The Storage of Carbon in Trees and Timber. Forestry Commission research division.

Penman et al. 2003. Good Practice Guidance for Land-Use change and Forestry. IPCC.

Outline of Procedure

In the field

1	Sub-divide the forest into strata *Areas with similar characteristics (species and size class distributions)*
2	Establish plots in each strata *Different sized sub-plots for different tree size strata.*
3	Measure the trees within those plots

At your desk

1	Derive a tree stem volume estimate for each species or group, where appropriate subdivided by size-class.
2	Estimate biomass in different part of the trees (roots & stump, main stem, branches & foliage).
3	Convert biomass estimates to carbon.
4	Present your results

Size Category	Definition	Plot side length (area)
Seedling	**A living stem less than 50 cm tall**	**10 m (0.01 ha)**
Sapling	**A living stem less than 50 cm tall with a dbh less than 7 cm**	**10 m (0.01 ha)**
Tree	**A living stem with a dbh greater than 7 cm.**	**14.1 m (0.02 ha)**

In the field

1. Sub-divide the forest into strata

Use the map provided to determine how you will stratify the forest. Each strata should have a similar species composition and size structure. Your strata should not be too small. You should define 2 strata. Make a note of where your strata are on your map. Make a note of how and why you decided to use these strata. Consider any areas with no trees – do you exclude these?

2. Establish plots in each strata

Number of plots

You should aim for 4-6 plots in total. Split these between your strata, putting more in the larger areas. Each strata must contain at least 2 plots.

Shape and size of plots

Your pots should be **square**. You need different sized plots for saplings and seedlings (10 x 10 m – though make this smaller if you have loads of saplings/seedlings), compared to trees (14.2 x 14.2 m). Use plots of the same size in each stratum. Mark the corner of your plots with a bag and use the 30 m tape to determine the edges of your plot.

3. Measure the trees within those plots

Record your data in the forms provided. Use one form per stratum. You do not need a new form for each plot. Note that these forms are the ones provided by the protocol—but they are quite clumsy to use!

Mature trees

1. Within each plot, measure and record by species the dbh of every living tree where this is 7 centimetres or greater.
2. Identify the two trees of each species nearest to the plot centre; these will be your height sample trees.
3. Measure and record dbh and timber height of the two height sample trees of each species.

Saplings

At each sampling point, **count and record the number of living saplings** of each species within a 0.01 hectare sample plot. **Measure and record the heights of the 3 saplings** of each species closest to the centre of each plot. Where there are fewer than 3 saplings of a particular species, the heights of all should be measured.

Count number of saplings. Use data form to tally the number.

Record the height of each of the three saplings in one box on the form.

Seedlings

At each sampling point, **count and record the number of living seedlings** of each species within a 0.01 hectare sample plot. Using a retractable tape measure, estimate and **record the height** (in centimetres) **of 20 seedlings** of each species. Individuals making up this seedling height sample should be representative of the seedlings present and should be selected from positions distributed evenly within the regeneration in the plot. Where there are fewer than 20 seedlings present, all should be assessed for height.

Record the height of each of the twenty saplings in one box on the form.

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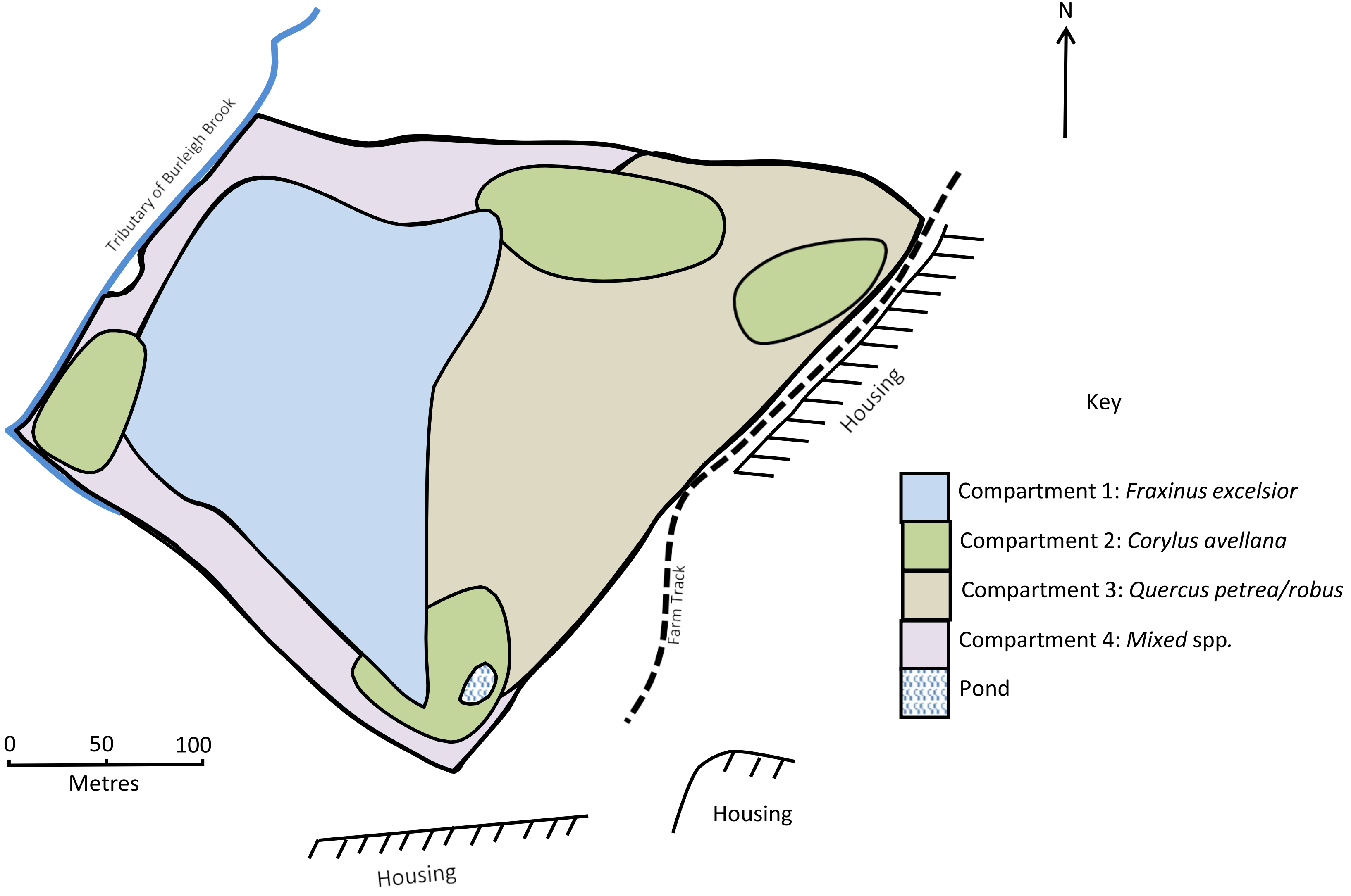
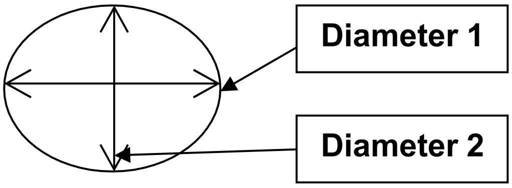


Map of Burleigh Woods

Measuring d.b.h. of problem trees

(taken from Husch B, Beers TW, Kershaw JA. 2003. *Forest Mensuration*, Wiley)

Use callipers to record the diameter of 2 perpendicular points on the stem at a height of 1.3 m above the ground, use the mean of these 2 measurements.



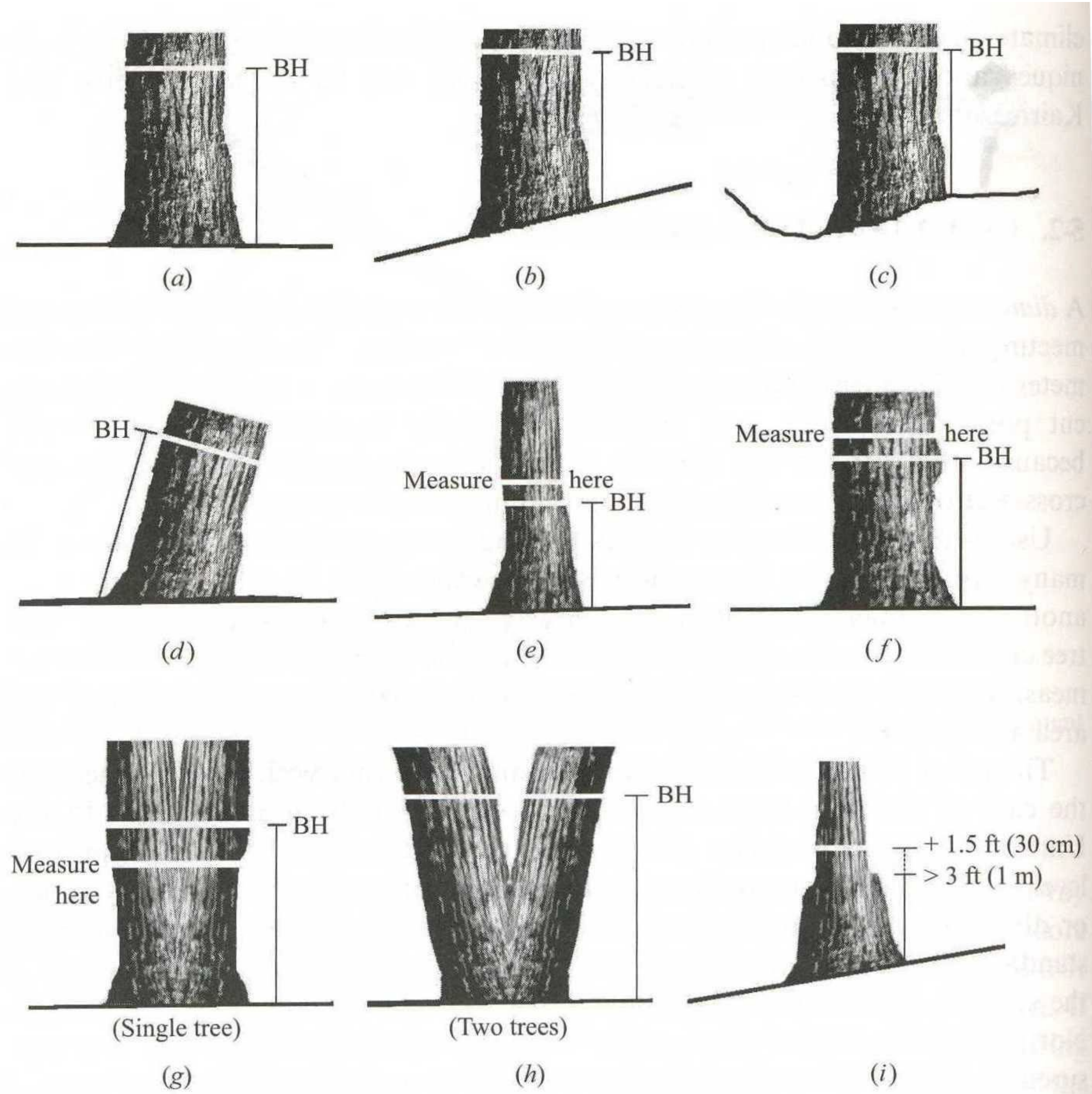


FIG. 5-3. Standard points for measurement of dbh: (*a*) level ground; (*b*) sloping ground; (*c*) uneven ground; (*d*) leaning tree; (*e*) crook at breast height; (*f*) defect at breast height; (*g*) forks at breast height; (*h*) forks below breast height; (*i*) buttressed tree. BH, breast height (4.5 ft in the English system, 1.3 m in the metric system).

Measuring Tree Height

From Mackie, E. D., & Matthews, R. W. (2008). Timber measurement: field guide. Forestry Commission.

Total height

The total height of a standing tree is the vertical distance from the base of the tree to the uppermost point (tip). The total height of felled trees is the straight line distance from the base to the tip. The total height of young standing trees can be measured with graduated poles. The total height of felled trees should be measured with a tape. The total height of other trees should be measured with a hypsometer or clinometer, and the instructions supplied with the instrument should be followed. **Each tree should ideally be measured from both sides**, and the two measurements averaged. The distance of the observation points from the tree should be in the region of 1 to 1.5 times the height of the tree.

Timber height

The timber height of a tree (or the timber length) is the distance from the base of the tree to the lowest point on the main stem where the diameter is 7 cm overbark. In hardwoods and occasionally in conifers this point may alternatively be the 'spring of the crown', i.e. the lowest point at which no main stem is distinguishable. It should be measured in exactly the same way as total height.

Note that when measuring tree height with a clinometer, you must measure the distance to the top of the tree AND the distance to the base of the tree. Then add these together.

20GYB08: Forest Ecology

Survey 2: carbon stored in woody debris

Introduction

Decaying wood is essential for the functioning of forest ecosystems. Snags (standing dead trees) and woody debris (dead wood on the forest floor) contribute to the biodiversity of a woodland by providing a habitat for insects (which are also food for birds), they are a large component of the forest carbon pool and contribute to nutrient cycling. Woody debris also has important impacts on stream and forest floor morphology.

You will measure woody debris (fine woody debris – FWD and course woody debris – CWD) in each of your plots using a line transect method. Basically this involves laying out a line on the forest floor and measuring every piece of woody debris that crosses that line. You will estimate volume by measuring the diameter of each piece of woody debris. While this only provides an estimate of biomass (which is the dry mass) this method is non-destructive, enabling repeated measures year-on-year. This method is used regularly for estimating woody debris for management and research purposes.

Further Reading

Enrong Y, Xihua W, Jianjun H. (2006) Concept and classification of coarse woody debris in forest ecosystems. *Front. Biol. China*, 1, 76-84.

Sturtevant BR, Bissonette JA, Long JN, Roberts DW. (1997) Coarse woody debris as a function of age stand structure and disturbance in boreal Newfoundland in *Ecological Applications*, 7, 702-712

Siitonen J, Martikainen P, Punttila P, Rauh J. (2000) Coarse woody debris and stand characteristics in mature managed and old-growth boreal mesic forests in southern Finland in *Forest Ecology and Management*, 128, 211-225

Nova Scotia Department of Natural Resources. Changes in deadwood structure following clearcut harvesting in Nova Scotia softwood forests Available from: http://www.gov.ns.ca/natr/library/forestry/reports/REPORT76.PDF

In the field

definitions

Coarse Woody Debris: CWD

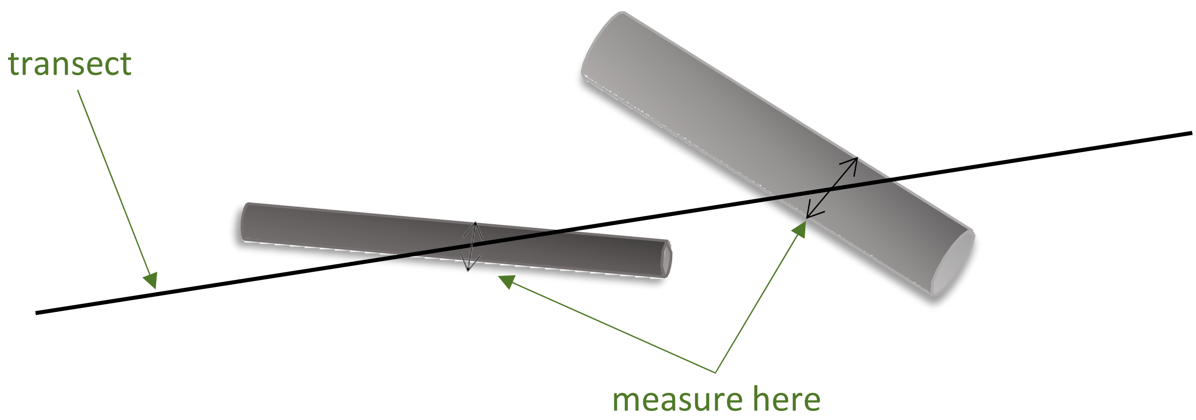
Dead woody material, in various stages of decomposition, located above the soil, larger than 10 cm in diameter (or equivalent cross-section) at the crossing point, which is not self-supporting.

Fine Woody Debris: FWD

Dead woody material, in various stages of decomposition, located above the soil, larger than 1 cm but less than 10 cm in diameter (or equivalent cross-section) at the crossing point, which is not self-supporting.

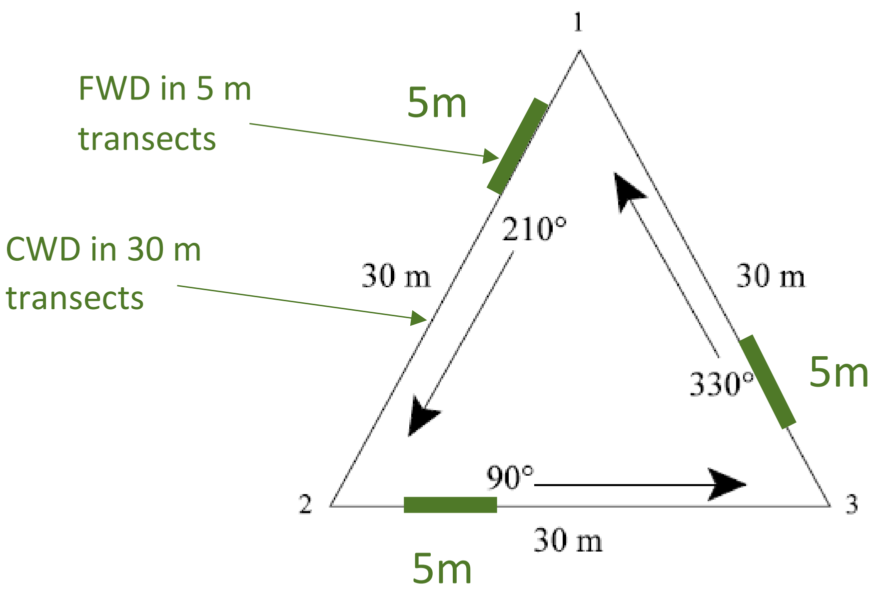
basic protocol

1. Locate start point.
2. Generate random angle
3. Measure 30 m in the direction of this bearing.
4. Walk along the tape and measure the diameter of every piece of dead wood (>10 cm diameter) that crosses the tape measure. Record the decay class of each piece also.
5. Choose a 5 m section of the transect and repeat 4 but for FWD (diameter >1<10 cm)
6. Lay out another transect at 60° to the first one.
7. Repeat 3, 4, 5, 6.
8. Repeat 3, 4, 5



Detailed instructions

1. Decide on the centre of the stand/area of study. Mark this (e.g. with a bag)
2. Generate a random angle (between 0 and 359 degrees using the random number table in Appendix 1. Chose a point in the table to start (doesn't matter where). Then work along the rows of numbers. For the first part of the coordinate you use the first number you come to that is between 0-3, then use the next number you get to between 0-6 and finally the next number (0-9) this should give you a 3 digit angle. Cross out the numbers you have used or skipped over so that you don't use them again.
3. Mark out a line 30 m long in the direction of your random angle.
4. Walk along the line and select and measure pieces of CWD that have a diameter >10 cm to be measured according to the sampling rules (Appendix 3). Avoid trampling or crushing the CWD. For each piece note the following:
   a. Tree species to a level that is reliable;
   b. Diameter in cm (where the line crosses the centre point of the CWD);
   c. Decay class based on the entire piece of CWD (using the descriptions in appendix 2)
5. Where pieces of CWD are suspended above the ground you may have to estimate the diameter.
6. If odd shaped pieces are encountered take 2 measurements and use the average;
7. Choose a 5 m part of the transect and measure FWD using the same protocol but for dead wood >1 cm but < 10 cm
8. At the end of your transect establish a new 30 m transect at 120º in an anti-clockwise direction. You will end up creating an equilateral triangle as below.



Definition of coarse woody debris

The following definition is taken from B.C. Ministry of Environment, Lands and Parks (1998) Field Manual for Describing Terrestrial Ecosystems. Accessed on 11th March 2009 from:
http://ilmbwww.gov.bc.ca/risc/pubs/teecolo/fmdte/deif.htm#table%20of%20Contents

Coarse woody debris (CWD) is dead woody material, in various stages of decomposition, located above the soil, larger than 7.5 cm in diameter (or equivalent cross-section) at the crossing point, which is not self-supporting. Trees and stumps (intact in ground) are considered self-supporting. (**note that you are using a diameter of >10 cm in this practical**)

Pieces of coarse woody debris may be suspended on nearby live or dead trees, other pieces of coarse woody debris, stumps or other terrain features.

Coarse woody debris includes:

- downed horizontal or suspended (not self-supporting) dead tree boles with or without roots attached;
- fallen trees which still have green foliage if they no longer have roots attached (no living cambium) to the ground to keep them alive;
- woody pieces greater than 10 cm at the point where the sampling line crosses the piece;
- uprooted (not self-supporting) stumps greater than 10 cm cm in diameter at the crossing point and any of their exposed dead roots greater than 10 cm in diameter at the crossing point;
- fallen broken tree tops which may be horizontal or leaning, or large fallen branches; and,
- recently cut logs.

Coarse woody debris does not include:

- dead branches still connected to standing trees;
- self-supporting (not overturned) stumps;
- exposed roots of self-supporting trees or stumps;
- material that is buried beneath organic or mineral soil layers or has decomposed enough to be part of the forest floor; and,
- live or dead trees (still rooted) which are self-supporting.

20GYB08: Forest Ecology

Survey 3: carbon stored in soil

Introduction

You will use loss on ignition (LOI) analysis to determine the organic matter content (%OM) of the soil in Burleigh Woods. You will then use %OM to estimate soil carbon content. LOI is a relatively simple method for measuring %OM. This method calculates %OM by comparing the weight of a soil sample before and after the soil has been ignited. This ignition removes all organic matter from the sample, so that all that remains is the mineral portion of the soil. The difference in weight before and after ignition represents the amount of OM that was present in the sample. Soil carbon is directly linked to soil organic matter (because this is where the carbon is found in soils). Soil organic matter (and so carbon) varies spatially within a forest, varies over time and can vary with depth (more organic matter at the surface)

Your measurement of soil carbon involves six stages. Those in bold you will undertake, stages 2 - 6 will be done for you.

1. Collection (Saturday practical)
2. Drying
3. Sieving
4. Weighing
5. Ignition
6. Weighing

Further Reading

Countryside Survey: England Results from 2007 (published September 2009). NERC/Centre for Ecology & Hydrology, Department for Environment, Food and Rural Affairs, Natural England, 119pp. (CEH Project Number: C03259). Available here: http://www.countrysidesurvey.org.uk/sites/default/files/pdfs/reports2007

Lai, R. 2005. Forest soils and carbon sequestration. Forest Ecology and Management. 220: 242-258. http://www.sciencedirect.com/science/article/pii/S0378112705004834

Vanguelova EI, TNisbet, TR, Moffat, AJ, Broadmeadow, S, Sanders, TGM, Morison JIL 2013. A new evaluation of carbon stocks in British forest soils. Soil Use and Management. 29: 169-181. http://onlinelibrary.wiley.com/doi/10.1111/sum.12025/full

9. collection

1. You will collect two small (i.e. a small handful) samples of soil from each of your plots in Burleigh Woods. One 0-10 cm depth and one from 10-20 cm depth.
2. For each plot take three samples (for each depth) and mix them together to form one sample per plot. For each of these sub-samples:
    a. Brush aside the leaves and surface layer of the soil.
    b. Use your trowel to remove a soil sample from the 0-10 cm layer.
    c. Use the trowel to remove a sample (in the same hole) from the 10-20 cm layer.
    d. Ensure that each sample represents the full extent of the soil layer being sampled.
    e. Keep these samples (0-10 and 10-20 cm) separate
    f. Do this again for two more sub-samples in different locations in your plot.
    g. Mix the three sub-samples together and place a small handful of this mixture in a paper bag. You should end up with one bag of 0-10m cm soi and one of 10-20 cm soil for each plot.
3. Label the bag carefully with your group number, the site and the plot number.
4. Place the paper bag in a plastic sample bag.
5. Replace left over soil back in the hole.

Appendix 2: Google Earth Engine

GYB201 Semester 2 – Week 8

Using Google Earth Engine to Examine Patterns of Temporal Change and Spatial Variability

Google Earth Engine (GEE) is a powerful online geospatial data processing facility. It is not a pure GIS, but it has GIS elements to it. As a company, Google has downloaded and makes available a great wealth of the many different free, publicly-available remote sensing datasets that exists (including all the Landsat missions, and the MODIS record). Google has also pre-processed a vast amount of raw satellite data meaning the final products are ready and available for use, and we don't have to concern ourselves with time consuming background preparation of the data we want to examine. Google stores all these data on its cloud, which can be accessed and processed through an internet connection using written commands in a simple programming language.

The power of GEE is that it allows access and processing of data very rapidly, with no need to download files and hold them in your own storage. The downside is that there is a learning curve to the code writing, which is not as 'friendly' as the ArcGIS graphical user interface (GUI) i.e. ArcMap's clickable buttons and tools icons. This means GEE requires a fai bit of experience to understand fully.

In this short opportunity we have to work with GEE, we don't have the room to explore its detail, or, explain its workings fully, but the instructions here will give you a good demonstration of its power and will allow you to rapidly extract some interesting, highly useable data for the Las Vegas project. It will also be good for you to have a go at some programming as you work with some GEE code (each bit of code is called a "script")..

[If GEE is of further interest, for instance for your dissertation, with more time, you would have more opportunity to experiment and tweak GEE code to help extract the data you need for your own dissertation. There are a lot of help resources and examples/templates of code you can cut and paste.]

- Signing up for GEE

You will need to sign up to have access to GEE, but the process should be quick. You can use your university account, or a private email address.

https://signup.earthengine.google.com/#!/

- Semester 2 Block 3 objective

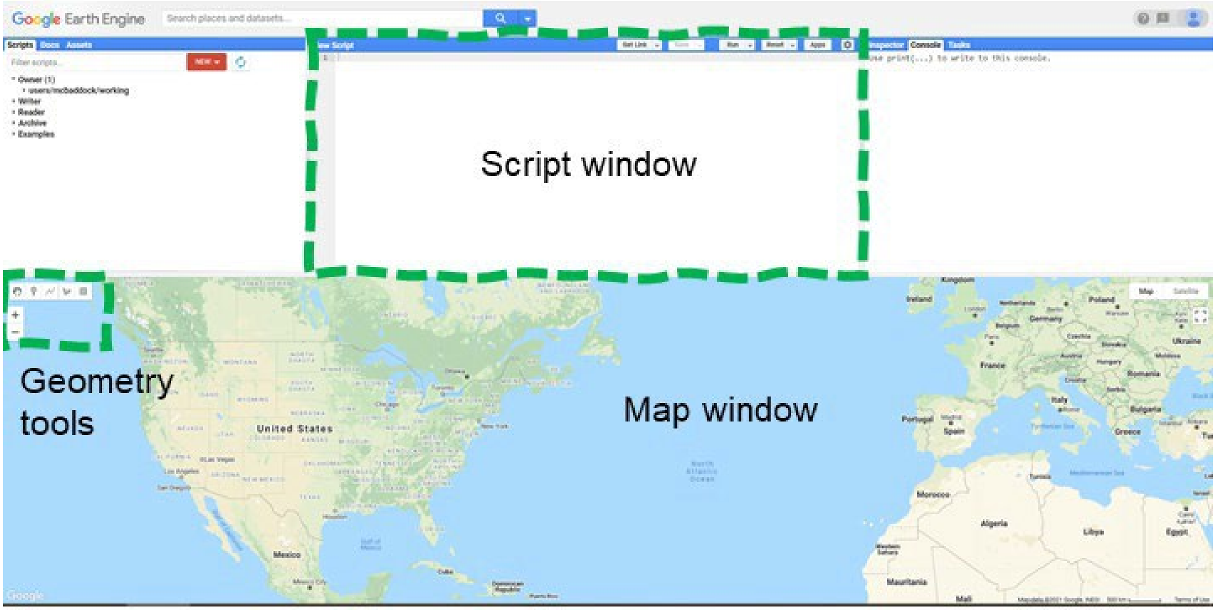
We will use GEE to address the following objective:

Objective 1) How does the NDVI i) magnitude and ii) pattern of temporal change, compare between golf courses in greater Las Vegas and natural mountain vegetation in the surrounding region?

Tackling the Block 3 objective

After signing up, you should receive permission right away. In your welcome email from GEE, click on the link to the Earth Engine Code Editor https://code.earthengine.google.com/

When you open GEE, you see a screen like so:



The Script Window will say "New Script" at the top. (If the third window on the top is missing on the right hand side, you will be able to drag it open using the grey divider edges.)

Click the following link to obtain the script you will be using to calculate NDVI by area.

https://code.earthengine.google.com/?scriptPath=users%2Fmcbaddock%2Fsharing%3AMODIS_NDVI_area_mean

When the script is in your Script Window, click the "Save as" button and navigate to your own users/ folder you have. Save as *MODIS_NDVI_area_mean*. You will see this script becomes saved in the left-hand window on the top.

- Some quick GEE script basics

In the script, the text that appears green, beginning with two backslashes (//) represents user-added comments that are included by anyone writing the code to help explain lines of it e.g. Line 1 is a description of the code. You can write/annotate any comments you like on a script (placed on a new line, or, at the end of a code line) as long as you begin with the //.

"***var***" throughout the script refers to the fact a new "variable" is being defined and named. When a new variable is being defined, ***var*** appears at the start of a line. So, in Line 3 of the code, a new variable called *ndvi_MODIS* is being created. The GEE operation, or function, that will then make the new variable is shown after the =

(So, in Line 3, a new variable named *ndvi_MODIS* has been created by a GEE function called *ee.ImageCollection* – basically this function calls the entire collection of MODIS NDVI data, MOD13A2 the red text in brackets, from Google's cloud.)

The content inside ({ …. }) are the definitions required by certain functions. For example, the instruction to make a chart from a lot of images (Line 9), is told to use the NDVI images (Line 10, for a certain study region (Line11) & that we require the mean to be calculated (Line 12).

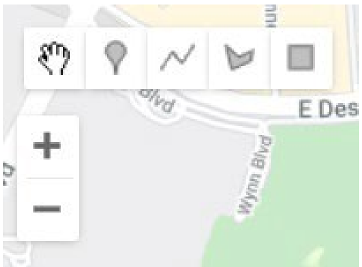
- Objective steps

To meet the objective, you will need to digitize the area of a golf course in Las Vegas. Drawing/defining a polygon area in GEE is a pretty similar process to ArcMap.

1. Zoom in on Las Vegas in the map window, and find a golf course. At the top right of the map window, there is a button for a satellite view that you can turn on. Each group member should work on a different golf course, so between you, you will sample several courses. Chat to make sure you are going to pick different courses.

2. Make sure you can see all the areas of your chosen golf course in the map window. You can drag the horizontal bar up to shrink the script window and see more map.

3. Click the jagged, irregular polygon shape on the Geometry Tools buttons at the top left of the map window.



4. Simply click on the map to draw an outline around your golf course. Double click to complete.

5. The default name provided automatically by GEE for any new shape drawn is “geometry”. To change the name, hover your mouse pointer over Geometry near the tools, then click the little cog icon which is Edit Layer Properties. Change the name to *golf_course_xxx* (where xxx is your first name.)

6. Click Save on the script window and then Run…

7. An error is thrown up!

On Line 4, change the yyy text to a start date. Use ‘2020-01-01’ entering exactly like that, in this specific date format, and with single quote marks. Likewise, replace zzz with an end date. For now, specify ‘2020-12-31’ for end date, so we look at all 2020. Run the model.

8. Ah, another error.

On Line 11, *your_study_polygon* is just a placeholder name. It doesn’t exist as a defined area. *region:* needs to be defined with the name of your actual polygon of interest, so change this to *golf_course_xxx* as you created (no quotes needed around *golf_course*). After debugging these two problems in the code, running it should now be successful. (N.B. every time you Run, it will save any changes made to the script, so you can Run rather than Save.)

9. Given the instructions in our code, due to Line 11’s command (*ui.Chart.image.series*), a chart will be created. Band mean on the y-axis is the mean NDVI value for your *region*. Note, these values need to be divided by 10000 to produced a true value of NDVI, so, 4000 is actually 0.4. (Remember NDVI always lies between +1 and -1.) See step 11 later on.

10. Change the date filters on Line 4 of the script to look at a longer, multi-year period.

The Terra NDVI data go back almost 20 years to 2001, but you might want to try 5 year periods at first. (Requesting a longer time period of study takes GEE more time to run.)

11. To extract the data values, click at the top right of any of your chart outputs, on the diagonal arrow icon. The chart opens in a new internet browser tab and you can click ‘Download CSV’ to get the data into Excel where you will be able to divide the data to scale it to +1 to -1, collate data (i.e. plot multiple golf courses on the same graph, and the comparison forest region), plus overall create a better quality plot/figure. (It is a lot easier to produce good graphs in Excel than GEE.)

Note the data download from GEE comes in an unhelpful, rather generic filename, so change this filename to something more helpful (e.g. referring to the *golf_course*) as soon as you have downloaded it.

Move the renamed file to your GYB201 working folder to keep your files organised.

12. For the objective, now you need to define a forest area to compare the golf course values and pattern against. Zoom out on the map window again, and use the satellite view to find a forested mountainous area. It is up to you where you pick, but look for some relatively dense forest. (Zoom right in to find where trees are! Jot down if an approximate location name can be found for your chosen forest area from the map.).

Hover over Geometry and *+new layer*. As steps 4&5 above, draw a new polygon that defines your forest area, then change the polygon name to *forest_xxx* (where xxx is your own first name again).

13. Edit the main script again, updating Line 11 *region:* to use your forest polygon name.

14. As a group, you will have now sampled a number of golf courses. Do some internet research to find out the name of the golf courses, and if necessary, the name of the forest region you picked.

You now have the procedures for obtaining data from GEE to address the Block 3 (and final) Semester 2 objective. Precisely how you answer the objective is up to you, as a group. You have this week’s and next week’s session to think this objective through, and gather the data to tackle it.

Ultimately, even though you will have sampled different forest areas between you, you should agree to use only ONE of the forest areas/Excel exported dataset to use as your comparison against the multiple golf courses you have.

Appendix 3: Night Lights

GYB201 Semester 2 – Weeks 5-6

Night Lights

Overview

In this block you are going to deal with a very special[1] set of 27 raster datasets, with each showing the annual mean intensity of nocturnal illumination from the Earth's surface at ~1 km resolution. They cover the period 1992-2018 and you can read more about how they were generated here. Block 2 will begin by giving you a taste of the insights that can be generated from analysing the night lights (which I hope you will keep in mind as you progress with your studies). This will be pursued through activities to be completed individually. You will then collaborate in your groups to track human development in Clark County using these data.

INITIAL INDIVIDUAL ACTIVITY

As you did in the first LST data-related block, please complete this activity individually (so that you are familiar with the methods and dataset), but feel free to discuss in your group's Teams channel that you have been working in.

Instructions

Adding the data to ArcMap

- Download all the night light raster datasets from here
- Once files have downloaded, unzip by right-clicking on the zipped folder, select "Extract All…" and ensure that you extract to the location of your choice before clicking "OK"
- Open ArcMap and add the "Harmonized_DN_NTL_2018_simVIIRS.tif" raster to the map (using the familiar "add data" button). You have just added the night lights dataset for the year 2018 (the most recent in the collection)
- Download the necessary shapefiles for this block from here. Unzip to a suitable folder, as before (I recommend a separate sub-folder – not in the same folder as the night lights raster files).
- Add the Countries_GCS shapefile to the map (and I suggest that you set the symbology to hollow, with red as the outline colour)

Exploring the data

It should immediately be apparent that luminosity (and therefore human activity) is extremely heterogenous across the surface of the Earth. You will notice, for example, that North America, Europe and parts of Asia burn very brightly, whilst other regions – such as the Tibetan Plateau, parts of South America, and central North Africa – appear dark and devoid of much human development. Even a cursory understanding of physical geography hopefully helps to explain some of this diversity. We recognise, for example, that the extreme heat and aridity of the Sahara is a challenge for humans,

[1] This dataset is, essentially, the story of our species' recent development as told to any distant observer.

and so too is the extreme altitude of the Tibetan Plateau. However, closer inspection reveals a more intricate picture, and dimensions to this story of human development that are unconnected with the physical side of our discipline. Navigate to the following features and reflect on what they show:

- *Longitude:* 31.3E *latitude: 30.5N*
- *Longitude:* 127.7E *latitude:* 37.6N (zoom out for context)

As you may have concluded from the second location, these data can be used as a proxy for economic activity. The power of this *set* of night light rasters, then, is in being able to track human productivity through space *and time* (if we assume that an upward trend in luminosity corresponds with economic development).

As a vivid demonstration of this, let us compare two rasters separated by just eight years.

- Add the 2010 raster to the map ("Harmonized_DN_NTL_2010_calDMSP.tif") and navigate to Northern India. Toggle between the layers (by ticking/un-ticking the checkboxes in the table of contents). What is the nature of the change that you are observing?
- Now navigate to 41E and 34.5N and zoom out until you can see the full extent of both countries either side of the international border. Toggle between the 2018 and 2010 rasters and:
  - (i) Describe the pattern (i.e., summarise the results) of the change that you observe
  - (ii) What process do you think this change reflects?

Evaluating differences with the raster calculator

We can highlight *differences* most easily by simply subtracting one raster from another. The result will then be the *change* in luminosity between the two years. Try this now by following the steps below:

- Create a new folder called "NL". We will save all the outputs from our processing there [for reasons that will become clear later, we want to keep the folder storing the night lights clear of any new rasters]
- Arc Toolbox > Spatial Analyst Tools > Map Algebra > Raster Calculator
- When the tool opens, indicate that you want to subtract the 2010 file from 2018 (Figure 1), then click OK once you have selected a (concise) name for your output, and directed the output to your working folder (not the default.gdb).
- When the new raster has been generated, explore it to view the change. Some of what we observe likely relates to "artefacts" in the generation of the data (apparent changes introduced by changing measurement practice through time: e.g., the darkening northward of 45N); but much of what you observe will reflect profound changes to human settlement between the snapshots.

Take another look at Syria in this 'difference' raster. Which city appears to have suffered the greatest darkening during between 2010 and 2018? [You may wish to have Google maps/Earth open in your browser to help you, and you may also be curious to browse press reports about this city].

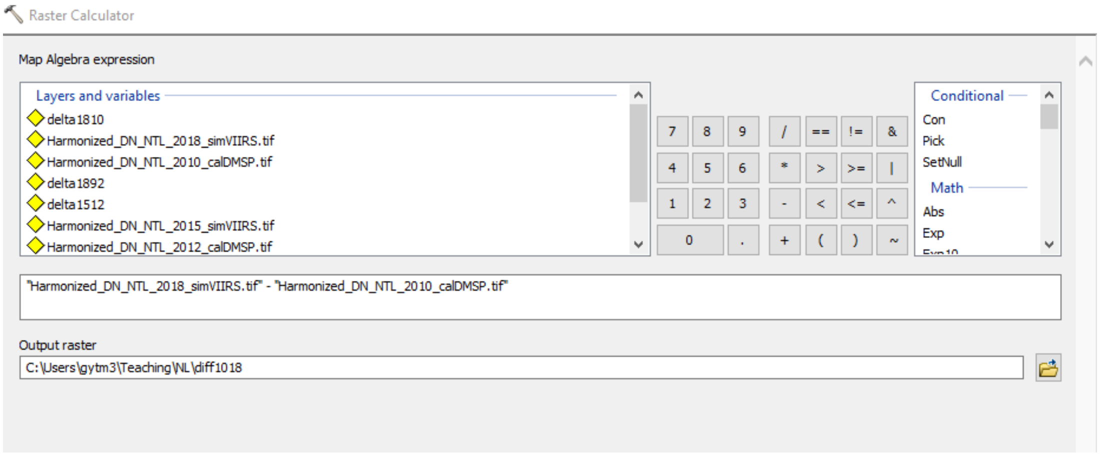


Figure 1. Setup of the Raster Calculator to evaluate the difference in luminosity between 2018 and 2010.

A very different type of disaster impacted the Caribbean in 2017, and it is detectable in the difference raster. Use this layer to locate the location of the disaster and comment in the space below on what you think you are seeing.

Computing Zonal statistics

As a complement to the spatial detail you see in the rasters, it can be very useful to evaluate the *mean* luminosity at some level of aggregation – for example at the national or state level. If we then compute the mean for each raster in our catalogue (1992-2018) we can track trends with time for the respective units (e.g., the mean luminosity for a country or state since 1992). To illustrate this, follow the instructions below to compute the mean luminosity for each country in 2018:

- Navigate to Spatial Analyst > Zonal > Zonal Statistics as Table and populate so that it looks like the below. You will need to change the output directory to match yours, but make sure that you save in the NL folder. Press OK when you are satisfied.
- Once the tool has run, right click on the output table in the Table of Contents [it will be called "mean2018" if you followed the example in Figure 2]
- Copy the fields in the table by left clicking in the **left hand margin of the first entry**, hold "ctrl" and "shift", and then click again in the **left hand margin of the last entry**. You can then **right click** in the margin and select "**copy selected"** (Fig. 3)
- Open up Microsoft Excel and paste the data into cell A1. This gives us a convenient, user-friendly way to inspect the aggregated data.

Using the values in the “MEAN” column, which country was the brightest on Earth in 2018?

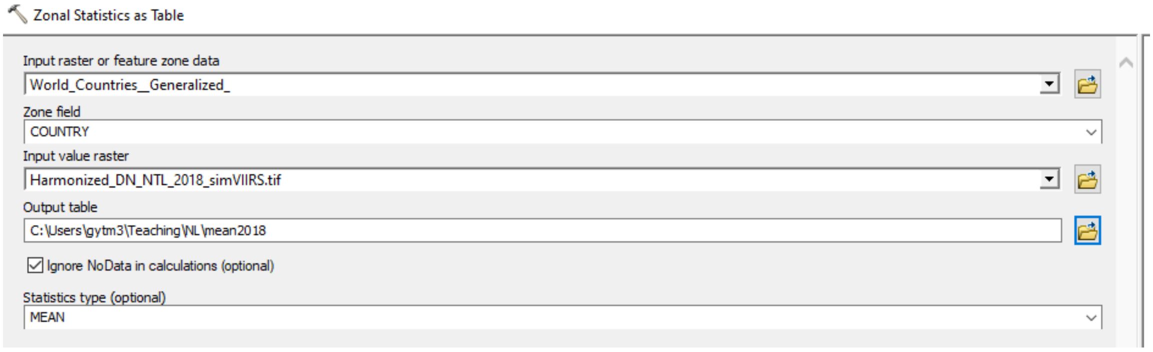
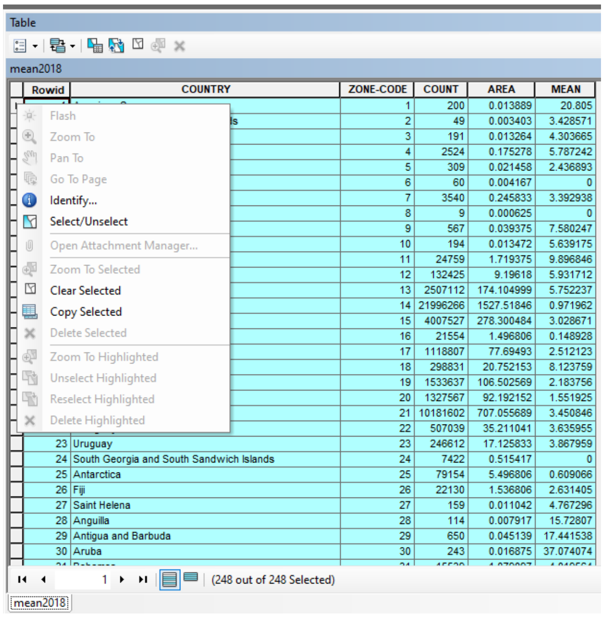


Figure 2. Setup of the Zonal Statistics as Table tool



Rowid	COUNTRY	ZONE-CODE	COUNT	AREA	MEAN
		1	200	0.013889	20.805
	...ls	2	49	0.003403	3.428571
		3	191	0.013264	4.303665
		4	2524	0.175278	5.787242
		5	309	0.021458	2.436893
		6	60	0.004167	0
		7	3540	0.245833	3.392938
		8	9	0.000625	0
		9	567	0.039375	7.580247
		10	194	0.013472	5.639175
		11	24759	1.719375	9.896846
		12	132425	9.19618	5.931712
		13	2507112	174.104999	5.752237
		14	21996266	1527.51846	0.971962
		15	4007527	278.300484	3.028671
		16	21554	1.496806	0.148928
		17	1118807	77.69493	2.512123
		18	298831	20.752153	8.123759
		19	1533637	106.502569	2.183756
		20	1327567	92.192152	1.551925
		21	10181602	707.055689	3.450846
		22	507039	35.211041	3.635955
23	Uruguay	23	246612	17.125833	3.867959
24	South Georgia and South Sandwich Islands	24	7422	0.515417	0
25	Antarctica	25	79154	5.496806	0.609066
26	Fiji	26	22130	1.536806	2.631405
27	Saint Helena	27	159	0.011042	4.767296
28	Anguilla	28	114	0.007917	15.72807
29	Antigua and Barbuda	29	650	0.045139	17.441538
30	Aruba	30	243	0.016875	37.074074

Figure 3. The output from the Zonal Statistics as Table tool

GROUP WORK

For the remainder of this block, you will be building on what you have learned so far to evaluate changes in luminosity through time within Clark County. Your challenge is to provide an account of changes in luminosity for Clark County during this observational period.

Please do this by completing the following objectives:

Objective 1: Produce a chart of mean luminosity in Clark County for the 1992-2018 period.

Objective 2: Visualise the spatial variation in changes with **at least one** map

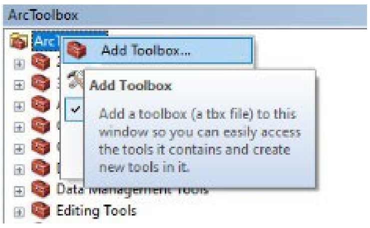
Objective 3: Compare the trends in luminosity experienced in Clark County with the rest of the United States of America over the same period. Has Clark County changed faster or slower than the national average?

There is more than one way to achieve each of those objectives, so please discuss as a team and implement a solution that you agree on.

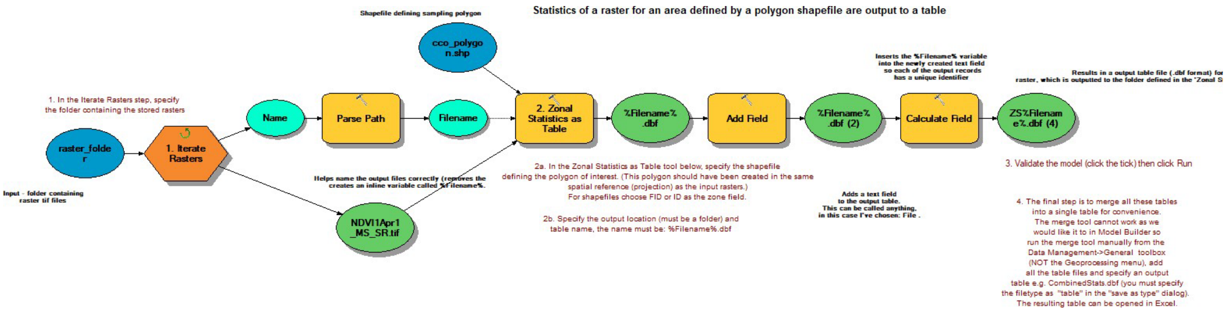
To help speed up your analysis, we have made a custom toolbox available to you. It can be downloaded from here. Instructions for how to apply it are in Appendix 1. Note that, you *could* complete the objectives without using it, but it will both accelerate your progress and limit opportunities for error.

Appendix 1 – A Toolbox for Computing Zonal Means for a Set of Rasters

Open Arc Toolbox, and right click on "ArcToolbox" text, then "Add Toolbox" (top of the menu, see below). You should then select the file you downloaded above ("20GYB201_stats_by_polygon").

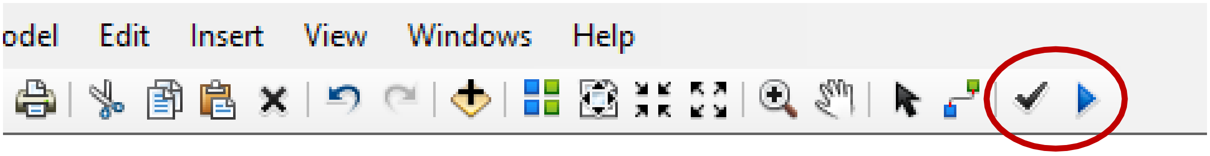


Once you have added the toolbox, you can launch it by first clicking the small cross (to see what is inside), then **right click** on 20GYB201_polygon_stats_looped and select "Edit". You will be greeted by a screen that looks like the image overleaf. Whilst this perhaps looks a little complicated to the uninitiated, it is remarkably simple to operate (so do not worry), and it is powerful: all we must do is set a few parameters, and it will then compute the zonal statistics for *all* raster datasets within the folder that we specify. Pretty much any type of repetitive task can be sped-up/automated with models like this in ArcGIS: they unlock the analysis of relatively big datasets and lay the conceptual foundations required to master computer programming. They are worth learning!



To run the tool, we just need to set a few *parameter values*:

- Double (left) click on the box titled “1. Iterate Rasters”.
    - In the “**Workspace or Raster Catalog**” field: enter the folder that stores the night lights raster data files* (leave the other fields unchanged). Click OK to close this window.
      *There should be no other (non- night lights) raster files in this folder.
- Double (left) click on the box titled “2. Zonal statistics as table”
    - In the “**Input raster or feature zone data**” field: enter the Clark_County_GCS shapefile (or, perhaps, the US_States_GCS shapefile – whatever you enter here will be used to define the region to compute the stats for).
    - In the “**Output table**” field: select the folder you want to save into (by selecting the little folder icon), and then type in: “%Filename%.dbf” as the filename (minus the speech marks!) Click OK when done.
- You are now ready to (1) **validate** and then (2) **run** the tool (circled below). Take these steps now.



- The model will take ~5 mins to run, but you will get frequent updates of its progress. Once it has finished, we need to **merge** all the .dbf tables it created:
    - Arc Toolbox > Data Management Tools > General > Merge
        - Navigate to the folder you stored the outputs of the model in (selected in the **output table** option above)
        - Select **all** the .dbf tables in this folder by clicking the first file, then hold ctrl + shift and click the last file (this will select *all* files), and then select “Add”.
        - Choose to save the output somewhere sensible (I suggest the same folder that the individual tables are in) and click OK to run the tool.
- Once complete, you can open the merged table and copy/paste to Excel. Follow the instructions from the individual activity section for guidance with that step.

Appendix 4: Sample Student Work

“Analysing the use of Microsoft Excel for the analysis of small-scale data”

B914710

20GYB327

CW2 PG Project 2

Microsoft Excel is one of the most powerful tools available to a geographer to facilitate analysis of the vast amounts of data produced by climate studies; being invaluable to summarise data and as a visualisation tool. This study will use the programme to establish the magnitude and temporal patterns of the temperature differences between urban parks and built-up areas and the urban heat island effect in Loughborough.

To compare temperature trends between a green space and a built-up area over approximately a month in Spring 2019, temperatures were measured using the campus automated weather station (hereby AWS) and a 'TinyTag' at the Geography Building (GB). The data was then summarised using Microsoft Excel 'pivot tables' into different timescale averages (15 minute, hourly and daily) and linear regression analysis and t-tests on the mean were carried out/ plotted at each. From Table 1 it is possible to see that at all timescales the coefficient of determination indicates that the variability in one of the temperatures is very well explained by the other (Moksony, 1999). There is a statistical difference between the mean temperature at AWS and GB, with the mean values for GB always higher than AWS at all timescales (Table 1). To try and identify where the largest variation was, timescales were plotted, Figure 1, from which, especially at hourly and 15-minute resolution, the biggest variation was found at high temperatures with GB having on average a 6°C warmer daily high than AWS, which is also visible on the linear regression plots. Our findings corroborate those of Torparlar et al. (2018); that temperatures were on average higher 0.9°C in urban parks than built-up areas due to local scale variation in heat absorption and storage in buildings compared with green spaces (Oke, 2006) (Alexander, 2021).

AWS data and data gathered by TinyTags at GB, may not be comparable, with TinyTags having an accuracy curve which can vary by approximately 0.2°C over our temperature range (TinyTag, 2019). Despite this not being a significant enough difference to explain our variation, the TinyTag located at the weather station was also considered in this study, and despite having statistically different mean values to the AWS, there was still on average lower that the GB values (Table 1). There are also assumptions of linear regression (and therefore R^2 values) and t-tests which all assume a normal distribution of temperature values (Meuleman et al., 2015)(Kim and Park, 2019)(Moksony, 1999). Histograms were plotted and there was a standard curve with a positive skew on hourly and 15-minute plots; daily values showed no clear frequency distribution; we must caution that these values may not be representative.

To determine the influence of the ‘urban heat island’ effect in Loughborough hourly temperature was taken from two weather stations, one at Sutton Bonington (rural) and from Loughborough University’s AWS (urban), for three months in early 2021. Our data were stratified using a dummy variable (where a value is given to a data point to indicate the presence or not of a qualitative factor (Alkharusi, 2012)) into night and day values (with the sunrise/sunset times used from the middle day of the month obtained from Suntoday (2021)). Using a ‘pivot table’, values for daily day/night average temperatures were extracted along with daily maximum and nightly minimum temperatures (Figure 2). A t-test was then carried out on the means of both these average and maximum/minimum temperatures (Table 2). From Figure 2 and Table 2, the nightly averages and nightly minimum temperatures were significantly lower in rural settings than urban areas (by 0.5°C and 0.76°C respectively) with not as significant differences in the daily average and maxima between settings. This corroborates the findings of Goddard and Tett (2019) who found a difference of approximately 2K (2°C) between the rural and urban nightly minimum temperatures, and no significant difference on daily peak temperatures.

Seasonality may be the probable cause of the difference in magnitude of differences between our study and that of Goddard and Tett (2019). Schatz and Kucharik (2014) found a 2°C difference in daily minimum between rural and urban settings in summer compared to a 1°C difference in the winter, which is more similar to our value obtained in winter months compared to Goddard and Tett’s (2019) longer term study from 1990-2017. The AWS values may not be representative of an urban environment, being in an urban green space, which, as mentioned earlier, results in lower temperatures. There may also be an issue with the stratification of the data into night/day, especially in the use of the nightly minimum, with the minimum temperature usually occurring approximately one hour after sunrise (Lönnqvist, 1962).

Small-scale data such as temperature records are vital in understanding local scale climatic variation and phenomena; in our case in quantifying and confirming both the effect that urban green spaces and built up areas have on temperatures, and also the urban heat island effect in Loughborough. Microsoft Excel is a powerful tool that can be used to process the vast amounts of data produced by these records.

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Appendix

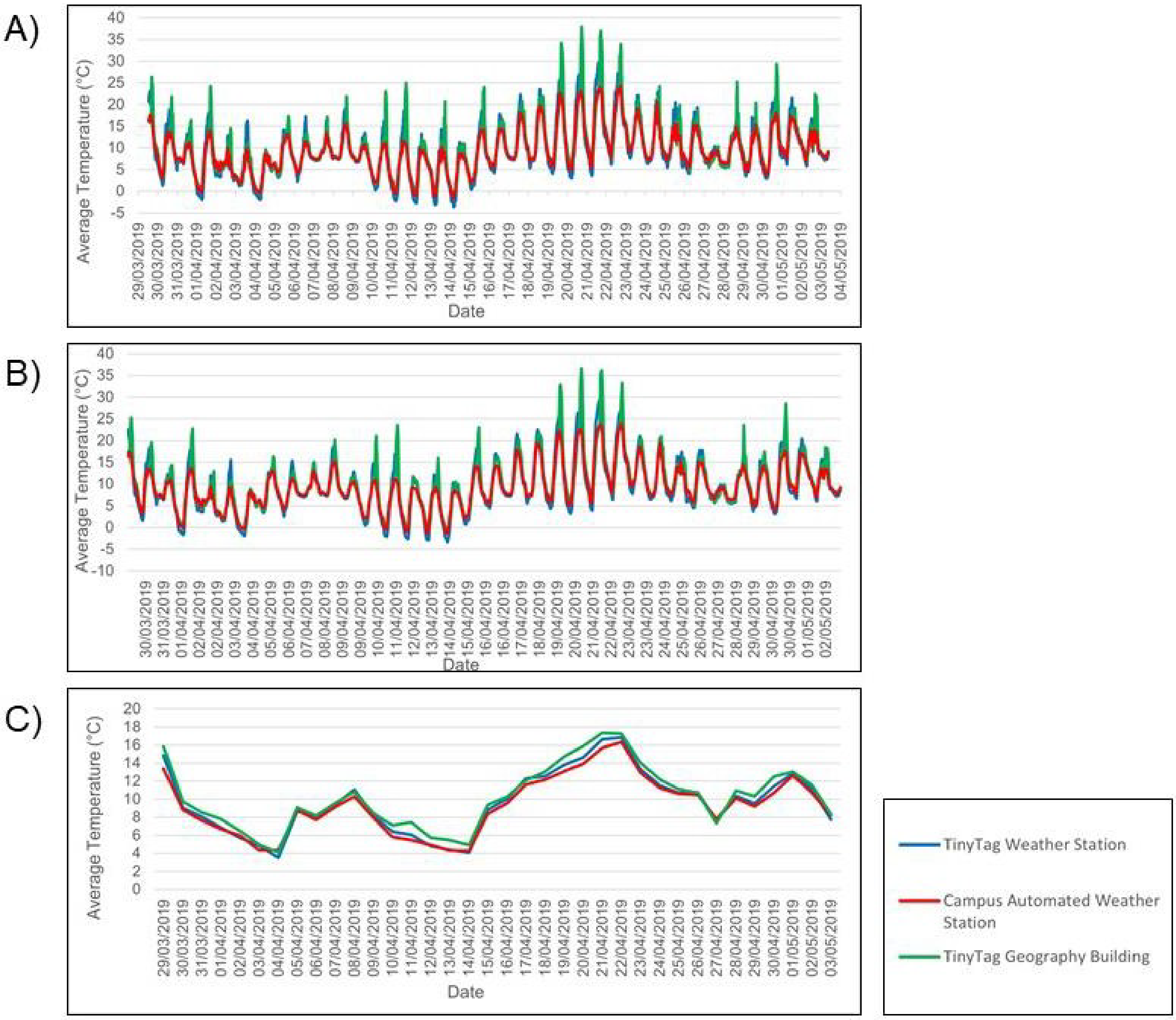


Figure 1: Time series of average temperature at the three different sites at a A) 15-minute resolution, B) hourly resolution and C) daily resolution. It is clear to see the higher peak in the Geography Building temperature at the 15-minute and hourly resolutions. Data source: AWS-Loughborough University (2021) TinyTag data- Unknown (Compiled by R Hodgkins, 2021).

Figure 2: Comparison of the mean daily/nightly temperature between the urban and rural sites, where the lower nightly mean temperature is visible to see in the rural setting. Data source: Met Office (2021), Loughborough University (2021) and Suntoday (2021). Map from Google Earth (Google, 2021). Centre co-ordinates: 1.283919°W, 52.791874°N.

Table 1: Comparing the Campus Weather Station, TinyTag at the Weather Station and TinyTag at the Geography Building. One can see clear statistical differences between the temperature records both in statistical tests and based on a visual inspection of the averages. Data source: AWS- Loughborough University (2021) TinyTag data- Unknown (Compiled by R Hodgkins, 2021). Please note: all temperatures given in °C and T-tests assume α=0.05.

			Geography Building vs Campus Weather Station	Geography Building vs TinyTag Weather	TinyTag Weather Station vs Campus Weather
R^2	15-min		0.96	0.97	0.98
	Hourly		0.97	0.97	0.98
	Daily		1.00	1.00	1.00
T-Test	15-min	T-stat	15.06	9.13	9.29
		T-crit		1.96	
		p	0.00	0.00	0.00
	Hourly	T-stat	7.72	4.74	4.92
		T-crit		1.96	
		p	0.00	0.00	0.00
	Daily	T-stat	8.36	8.03	4.39
		T-crit		2.03	
		p	0.00	0.00	0.00
			Campus Weather Station	**Geography Building**	**TinyTag Weather Station**
Mean	15-Minute		9.27	10.11	9.58
	Hourly		9.27	10.11	9.58
	Daily		9.32	10.17	9.36
	Average		9.29	10.13	9.51
Difference from Campus Weather Station			0.00	0.84	0.22
Daily Maximum			14.69	20.67	
STATISTICAL DIFFERENCE				NO STATISTICAL DIFFERENCE	

Table 1: Comparing Sutton Bonington (rural) to the Campus Weather Station (urban). Interesting to note is the change in significant difference between monthly averages and the raw data for daily average temperatures. One can clearly see greater differences in both average and minimum temperatures compared to daily values. Data source: Met Office (2021), Loughborough University (2021) and Suntoday (2021). Please note: all temperatures given in °C and T-tests assume α=0.05.

		Sutton Bonington		Campus		Day Difference	Night Difference
		Day	Night	Day	Night		
Average Temperature	December	5.90	4.80	6.00	5.30	0.10	0.50
	January	4.10	2.70	4.30	3.40	0.20	0.70
	February	6.30	4.70	6.40	5.00	0.10	0.30
	Average	5.43	4.07	5.57	4.57	0.13	0.50
	T-test		Monthly resolution		T-stat	1.03	5.01
					T-crit	4.30	
					p	0.41	0.04
			Raw data		T-stat	2.63	7.38
					T-crit	1.99	
					p	0.01	0.00
Average Daily/ Nightly Minimum and Maximum Temperatures		6.92	1.84	6.85	2.60	-0.07	0.76
		T-test			T-stat	1.44	7.15
					T-crit	1.99	
					p	0.15	0.00
STATISTICAL DIFFERENCE				NO STATISTICAL DIFFERENCE			

Appendix 5: Soil Science

Soil Science Project

GYB911 Physical Geography Field course

Soil Science Project outline

09:00 – 10:00 - Activity Briefing

- Introduction to Soil Science
    - Components of soil, Soil texture, Soil structure, Soil profile, Soil pH, Soil nutrients

- Introduction to project (aim and research questions)
    - Aim and research question
    - Field site and transect
    - Field assessment techniques
    - Lab analysis
    - Post field and lab work
    - Presentation guidance.

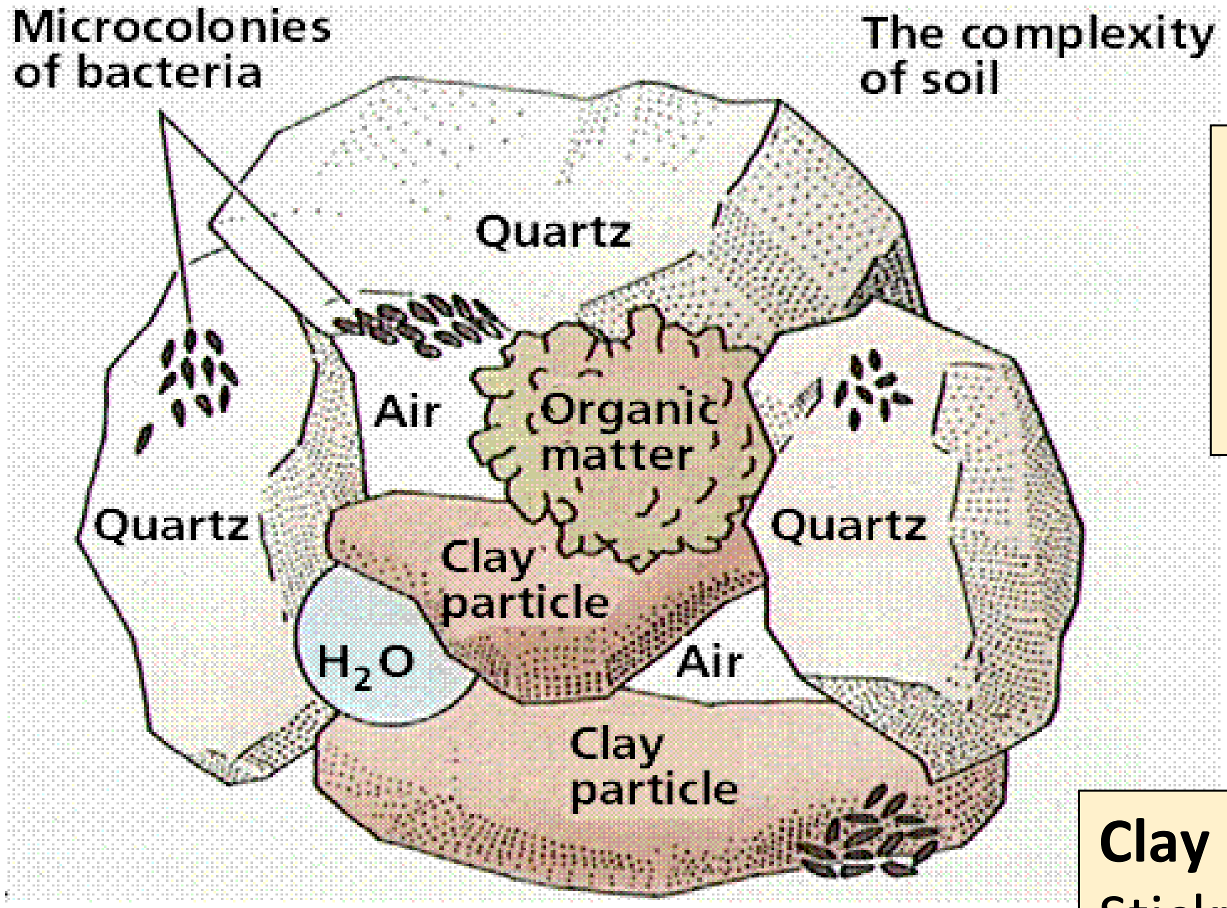
10:00-12:30 - Field work
12:30-13:30 - Lunch
13:30-15:00 - Lab work
15:00 - Access to teaching home available to complete field notebooks/ fieldwork reflection

What will we be looking at today?

Examine how land use influences a range of soil properties across the Loughborough University Campus.

Background: Components of soil

Organic matter
Provide nutrients; maintain flora/fauna; water retention



Sand (2.0-0.6mm)
Gritty feel; promotes drainage/aeration; can't retain water

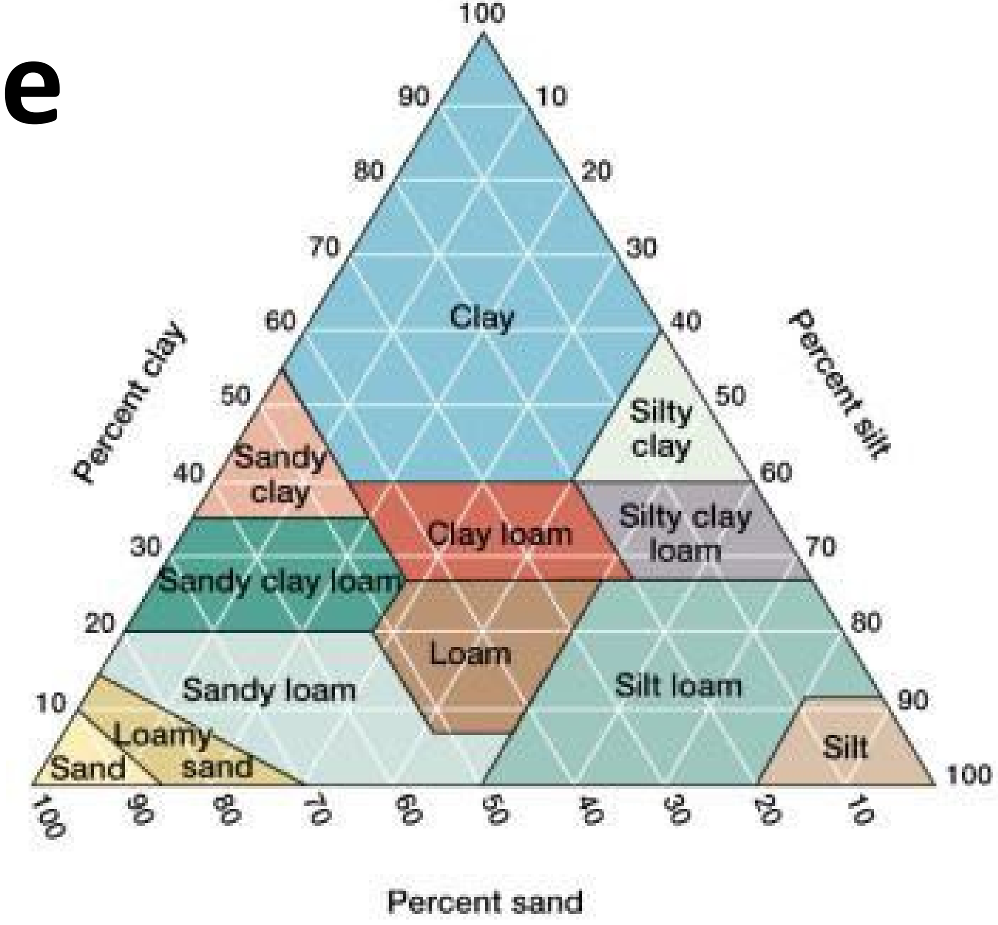
Silt (0.06 – 0.002 mm)
Micro-sand particles (smooth when wet); promotes water retention

Air/pore space
Aeration/drainage

Clay (< 0.002 mm)
Sticky and mouldable; promotes water and nutrient retention; poor drainage due to particle size

Background: Soil texture

- Soil texture refers to the relative fractions of sand, silt and clay.
- Soil texture is very important for soil water interactions, chemical properties & biological activity.
- Soil texture effects the type of cultivation practices & subsequent crop yields.
- Soil texture can be amended (amelioration) i.e. add sand to sports pitches to improve drainage by increased aeration)

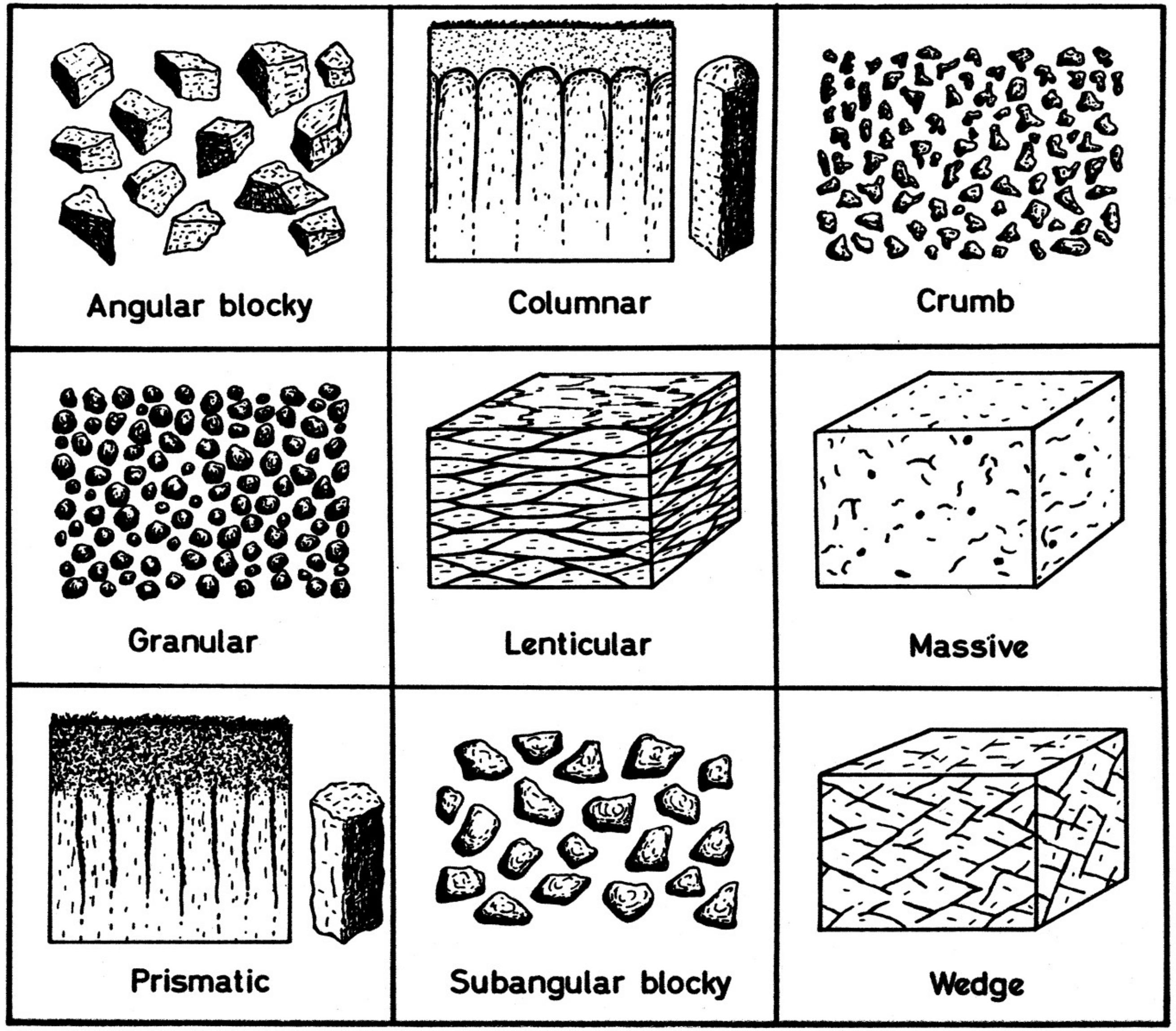


Rowell (1994)

Influence of soil texture on soil properties

	Sand	**Silt**	**Clay**
Water-holding capacity	Low	Medium	High
Aeration	Good	Medium	Poor
Drainage	High	Slow	Very Slow
Nutrient retention	Low	Medium	High

How are soil particles/aggregates aligned - Soil Structure



(FitzPatrick, 1986)

Blocky size descriptions	Size (mm)
Small blocks	< 5 mm
Fine	5 - 10 mm
Medium	10-20 mm
Large	20-50 mm
Coarse	> 50 mm

Examples of soil structural types

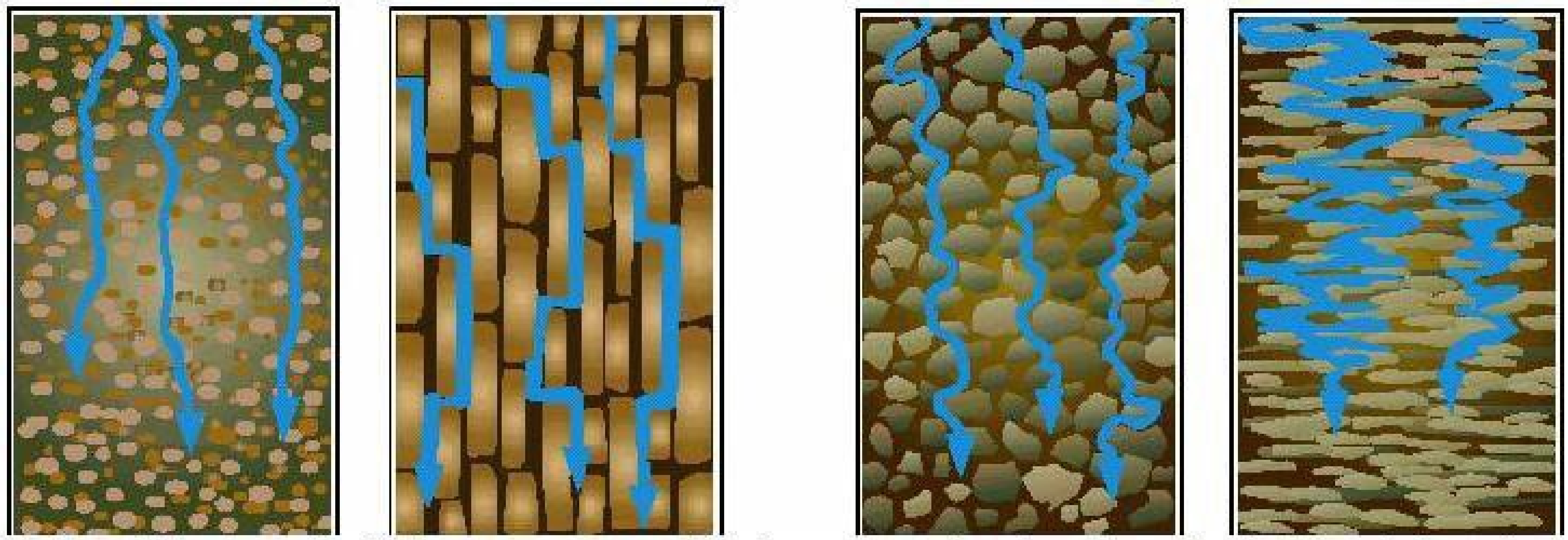
Top soils

Sub-soils

Environmental Agency

Why is soil structure an important measurement?

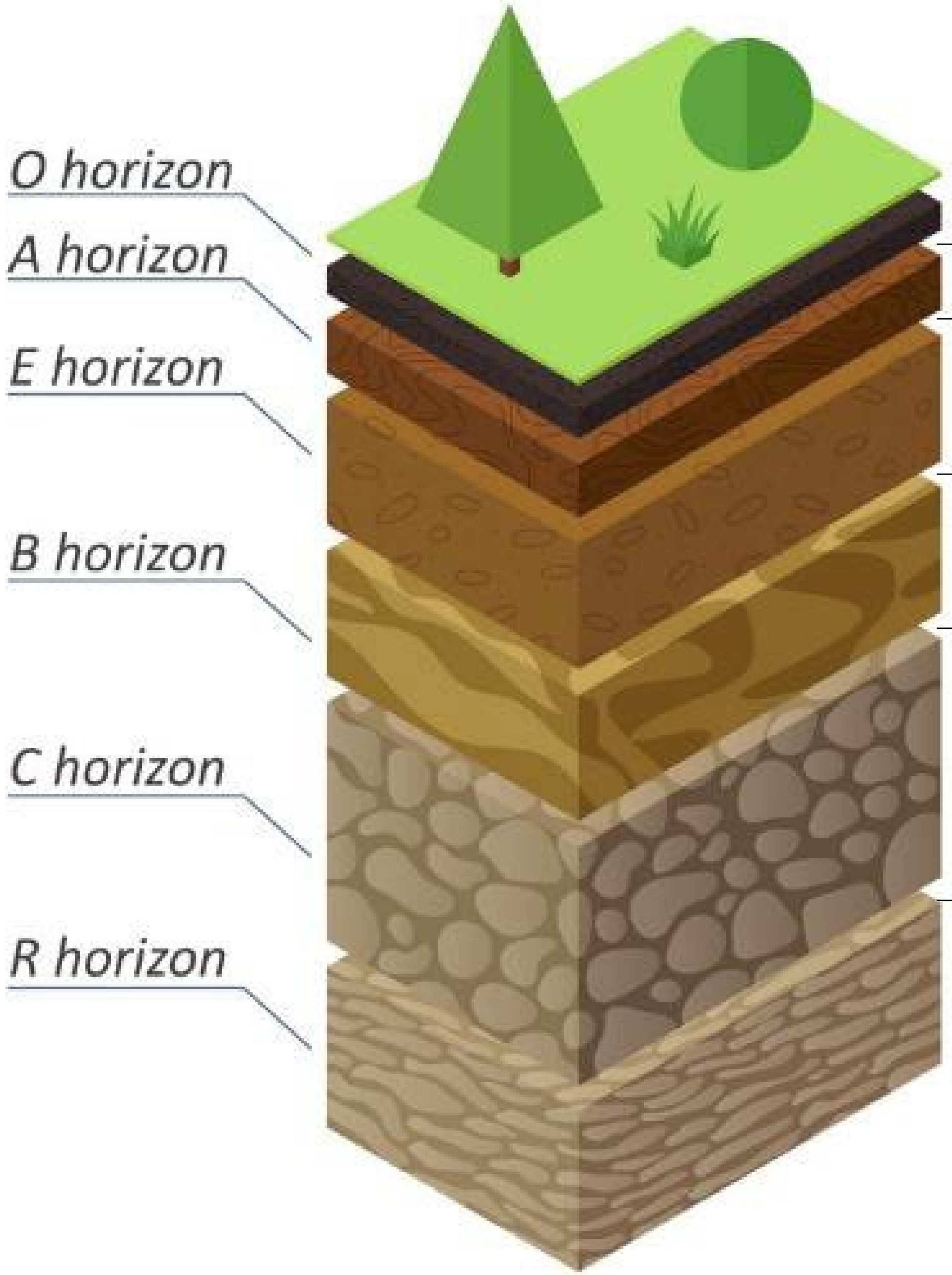
Soil structure is a measure of the pore space in soils. Pore spaces influence the transfer of gases and water (and nutrients) within a soil. It also forms the habitat for key soil biota.



Preferentail flow - gravitational water movement through granular, prismatic, subangular blocky, and platy soils [5] (left to right).

http://www.soils.umn.edu

Soil Profile



Litter layer of plant residue.

Layer of mineral soil with most organic mater accumulation and soil life.

Pale layer of silicates. This soil is called elluviated as mineral and organic material has been leached.

This layer accumulates iron, clay, aluminium and organic compounds, illuviated layer. It is the sub-soil.

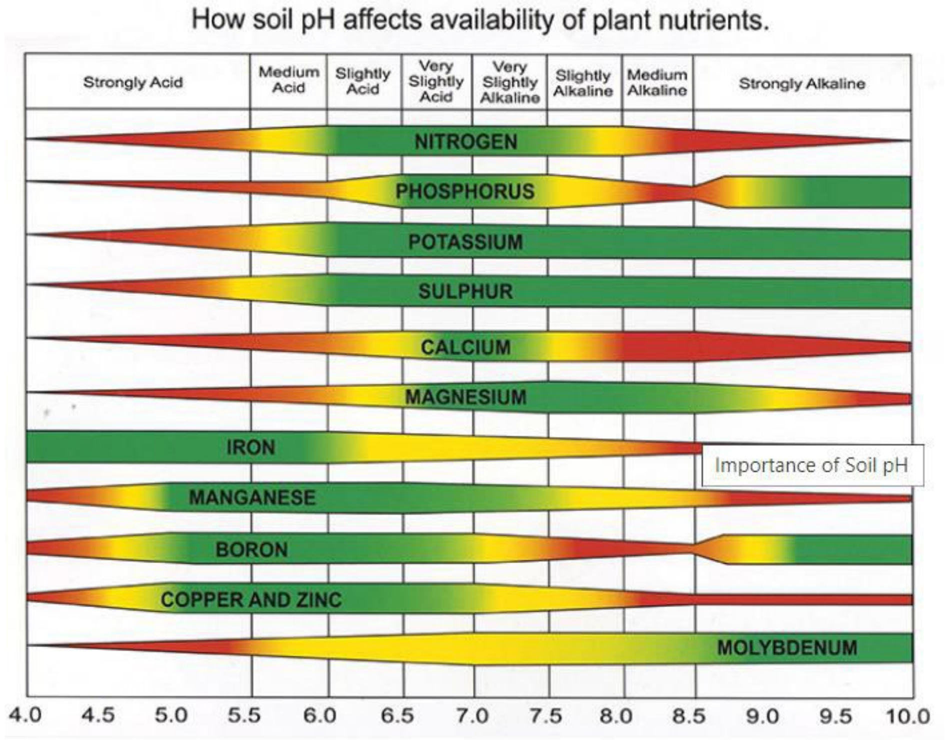
Parent material, either from deposits(e.g., flood deposits or landslides) or it formed from weathering of residual bedrock

Bedrock (base of profile).

Soil pH

The relative acidity or alkalinity of soil is indicated by its pH. The pH is important because it influences the availability of essential nutrients and the biota that live within the soil habitat.

A pH of 7 indicates a neutral soil. Most horticultural crops will grow satisfactorily in soils having a pH between 6 (slightly acid) and 7.5 (slightly alkaline).



https://www.jonathangreen.com/importance-soil-ph.html

Soil pH	Bacteria (millions g^{-1})	Fungi (thousand g^{-1})
7.5	95	180
7.2	58	190
6.9	57	235
4.7	41	966
3.7	3	280
3.4	1	200

West, H.M. (2014) Introduction to life in soils. Lecture.

Soil nutrients

Soil is a major source of numerous nutrients. The three main nutrients are **nitrogen (N)**, **phosphorus (P**) and **potassium (K**) and are required for any vegetation growth. Together they make up the trio known as NPK. These nutrients demonstrate how fertile a soil is.

NPK can be derived from organic matter, inorganic fertilisers and animal manure. It can be measured as nitrate, phosphate & potassium as these are the available forms within the soil.

What will we be looking at today?

Aims:

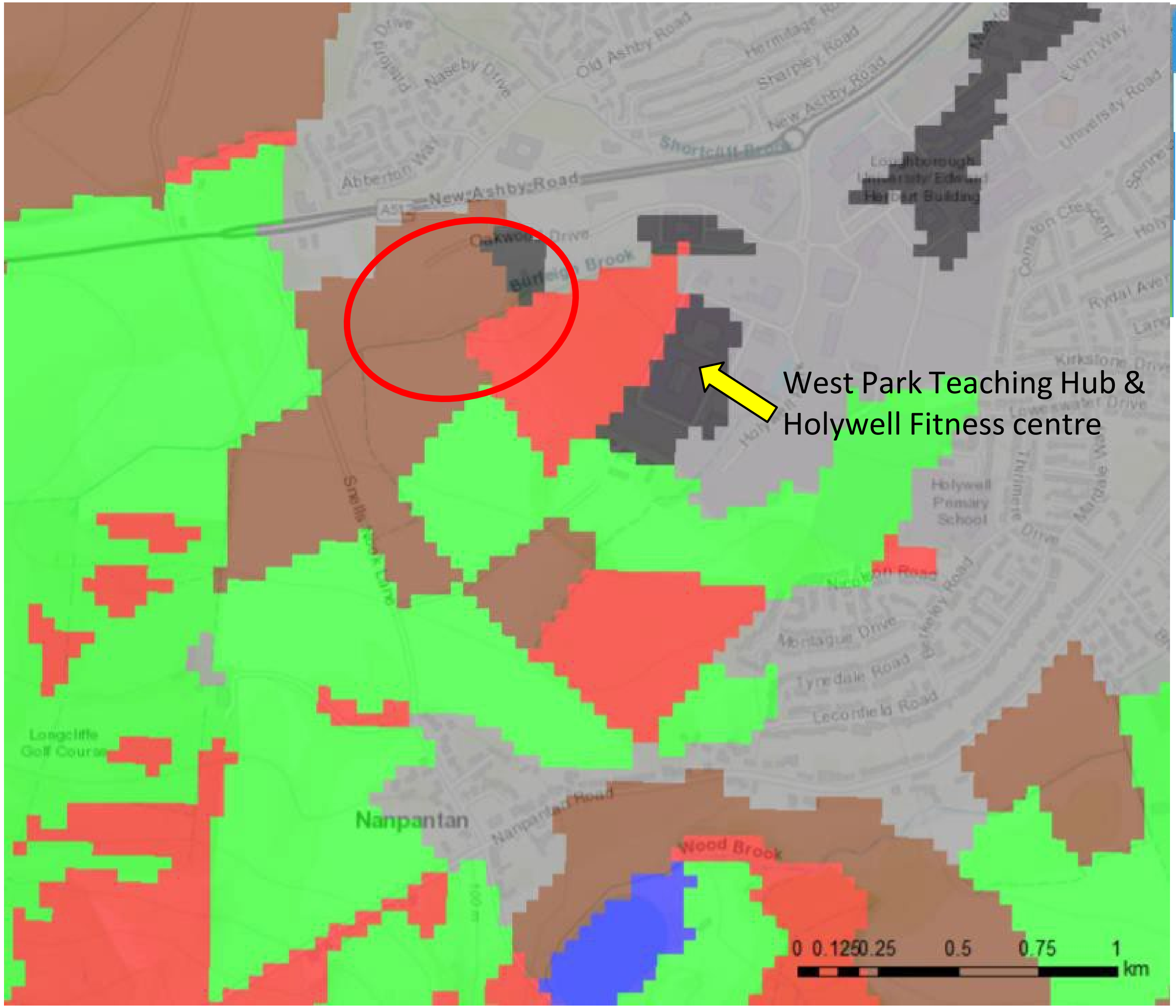
1. Examine how land use influences a range of soil properties across the Loughborough University Campus.
2. Use this data, to hypotheses the potential impact that converting Holywell woods to either arable or grassland would have on the soil properties.

Research hypotheses

i. changes in land use alter soil properties (i.e. soil quality indicators) and that

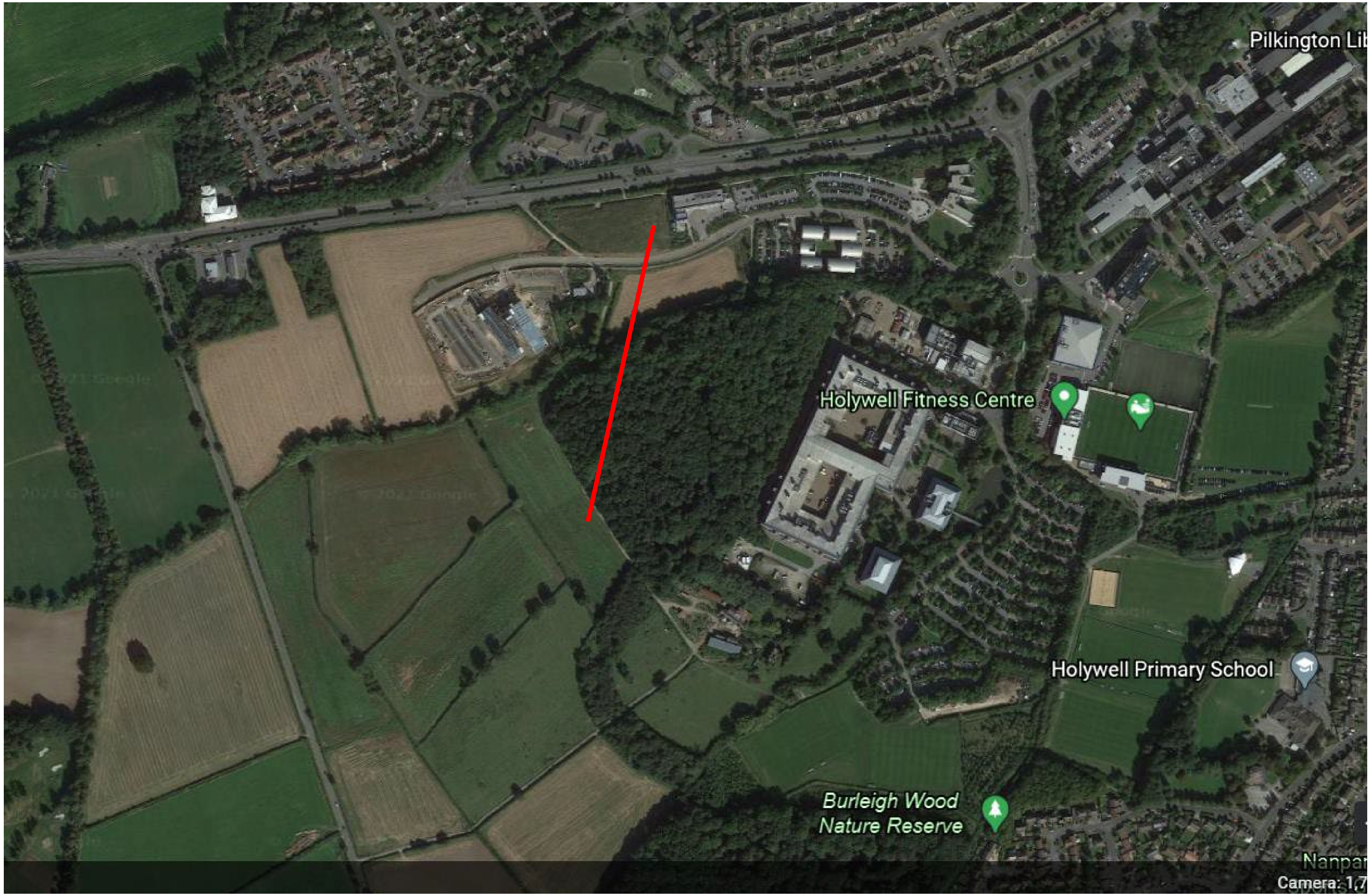
ii. the conversion of the deciduous Holywell woodland on campus to either arable farmland or grassland would lead to the deterioration of soil quality parameters.

Land use on the West campus

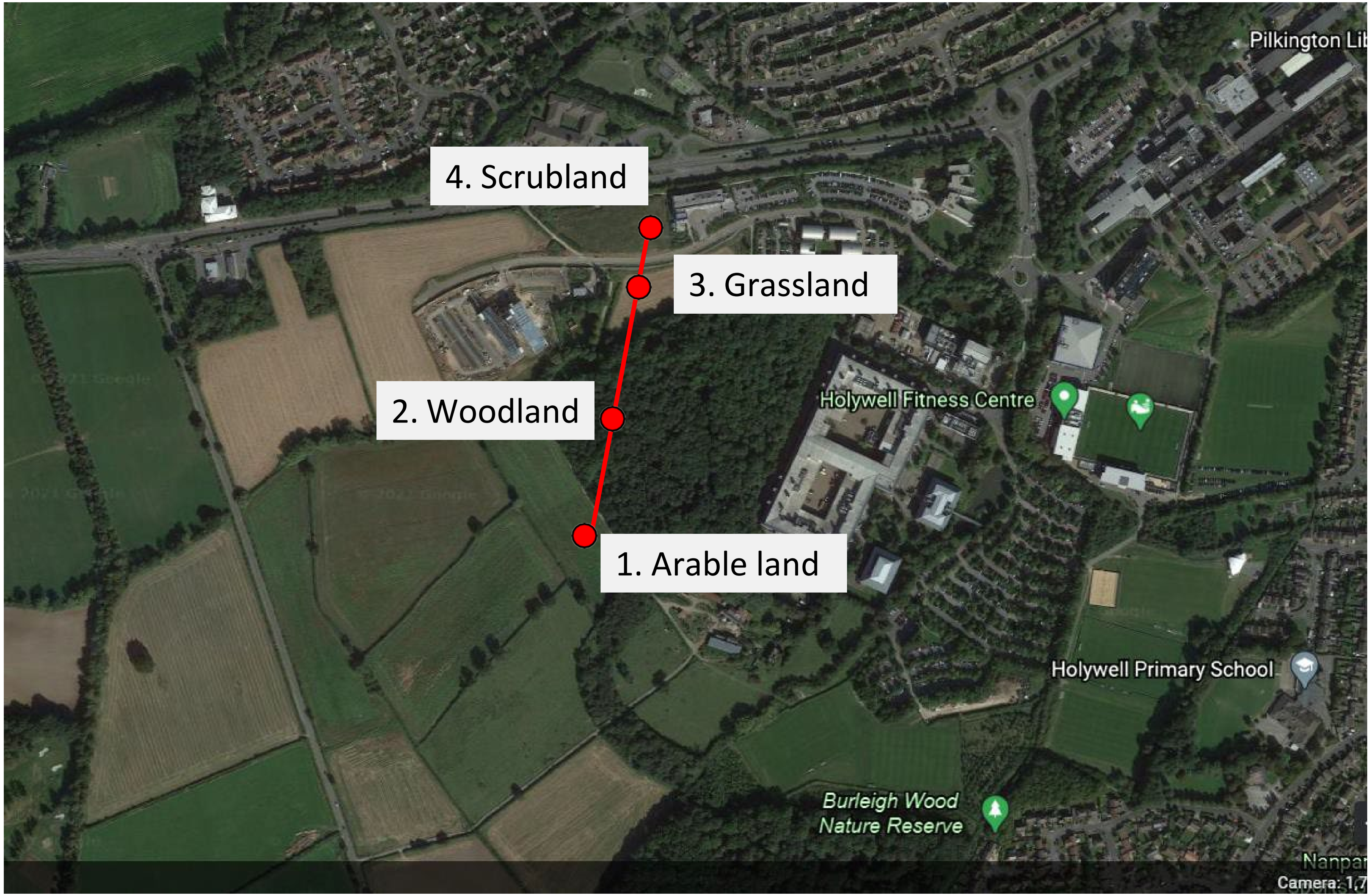


http://mapapps2.bgs.ac.uk
/ukso/home.html

Field sites on a transect within West park



Field sites on a transect within West park



Field site introduction

1. **Arable land:**
- Intensive arable land.
- Been farmed regularly for numerous years.
- Receives fertiliser amendments throughout the growing season.

2. **Holywell Woods:**
- 6.7 hectares in area.
- Ancient woodland origin.
- Trees present today are relatively young (self set) due to felling in 1940s to provide timber for war effort.
- Listed on Leicestershire inventory of ancient woodland.
- Ash, oak, hazel and silver birch present with highly developed shrub layer.

3. **Grassland:**
- Used to be arable land.
- Converted to grassland prior to construction of Advance Institute of Technology Centre 2015-2016.
- Grass is cut throughout the growing season.

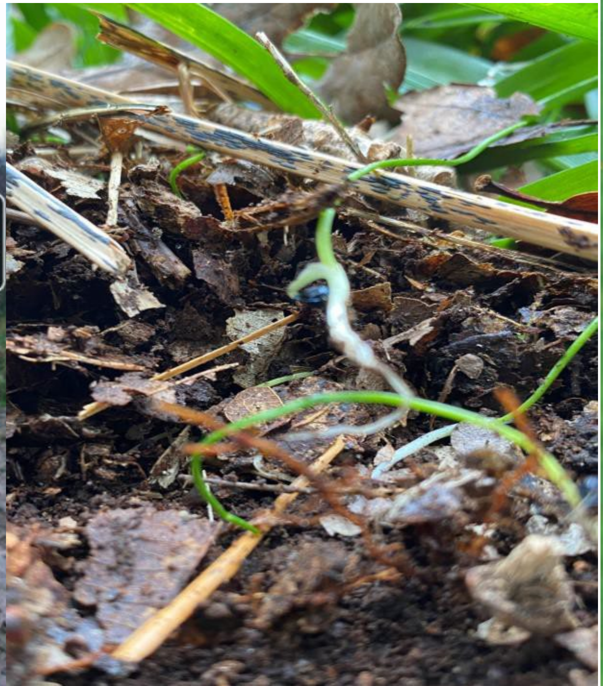
4. **Scrubland:**
- Used to be arable land.
- Amended by the building of the Advanced Institute of Technology Centre between 2015-2016.
- Now left as unamended grass/scrub land.
- No cutting or management.

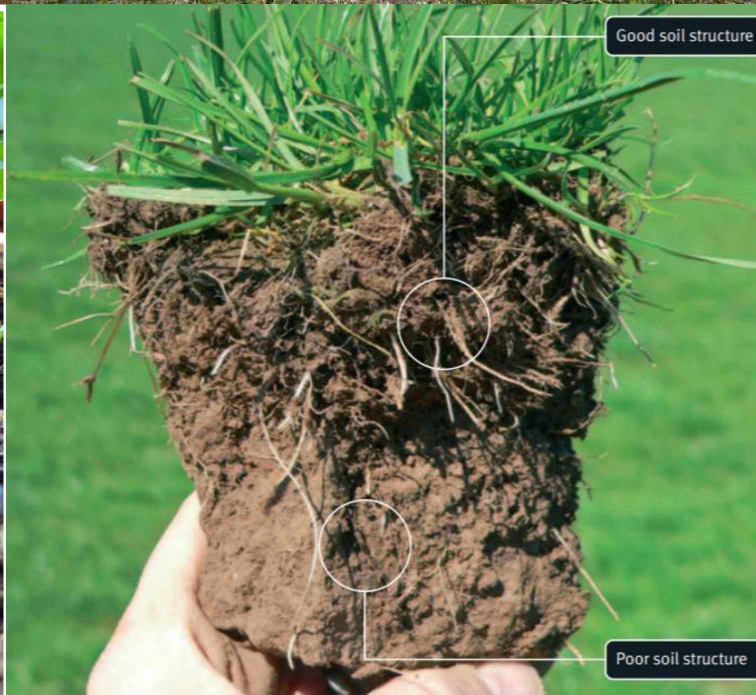
How will we measure soil quality:

- Soil texture (% clay content)
- Soil structure
- Soil colour
- Soil shear strength
- Soil pH
- Soil moisture content
- Soil organic matter content
- Soil phosphorus content
- Soil nitrate content

Site description

- Land use
- Vegetation cover? If so, what?
- Root content
- Litter layers?
- Signs of compaction?
- Machinery usage



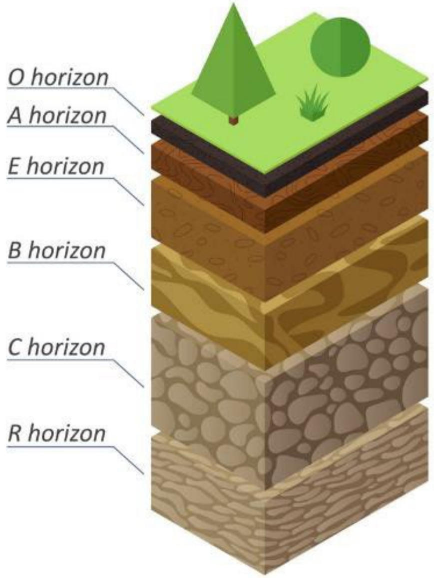


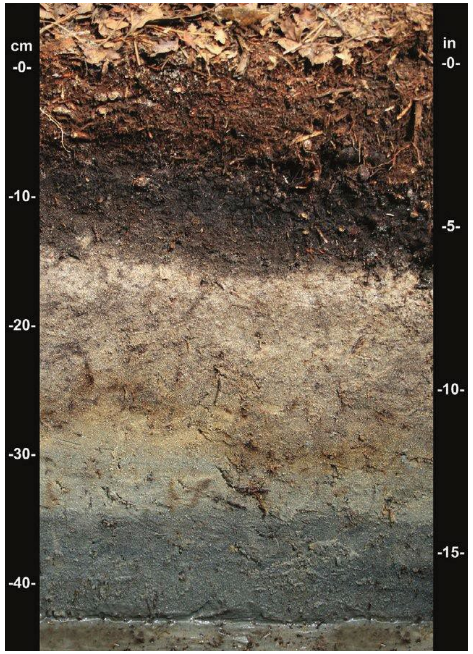
Field: Soil profile description

Describe 0-10/15 cm of soil profile (O and A Horizons):

- Is there a defined O Horizon (litter layer)? How deep?
- Can you only see an A Horizon?
- Are there any roots? How deep do they go in your pit?
- Are there any stones? State a rough percentage?

- In your field notebook quickly sketch the appearance.
- Give details of land use, vegetation cover and machinery/amendments noticeable?





Vasilas et al. (2008) Field Indicators of Hydric Soils in the United States. USDA.

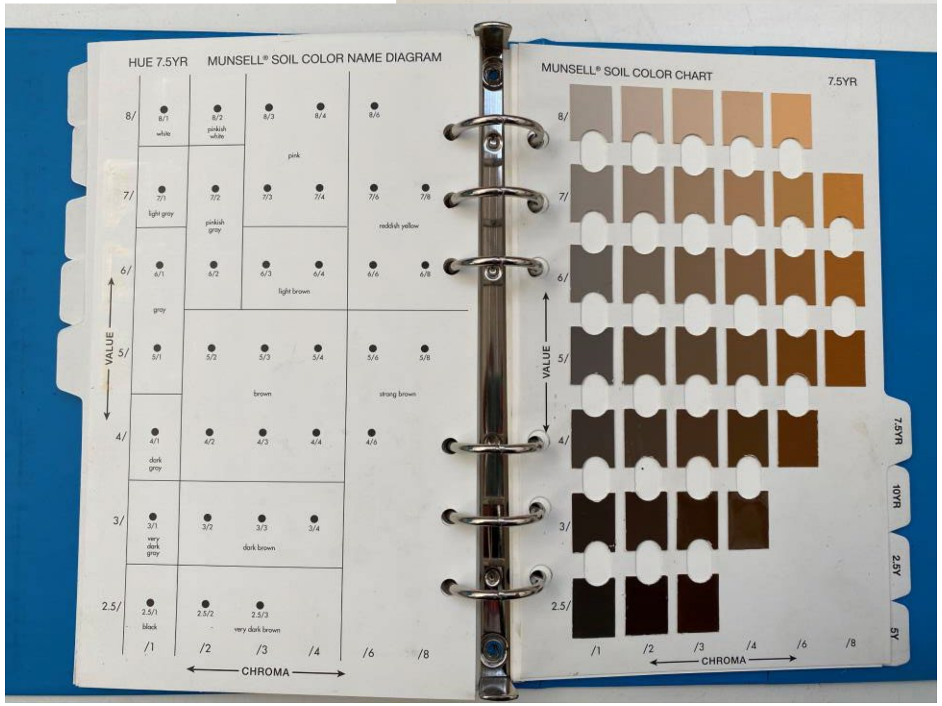
Field: Soil colour – Munsell colour charts

Gives an idea of the mineral make up of soil and type/quantity of organic matter.

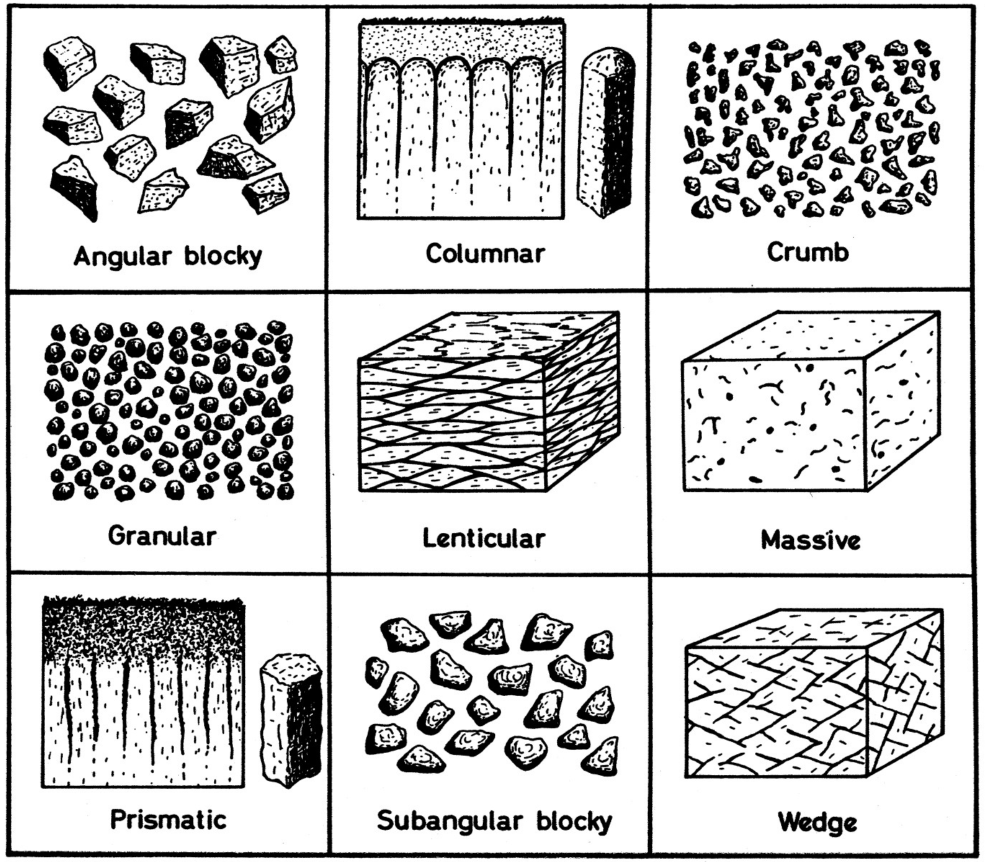
In the Munsell colour system, colour is expressed in terms of hue (basic colour), value (lightness or darkness), and chroma (intensity of basic hue).

Use the colour charts to select the hue/value/chroma that matches your soil. Record in your field notebook.

Take a colour swatch (rub it in your fieldnote book).



Field: Soil structure

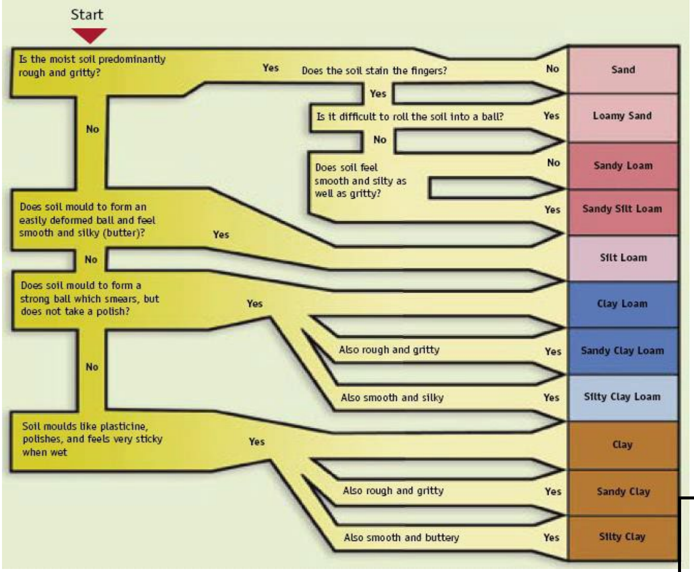


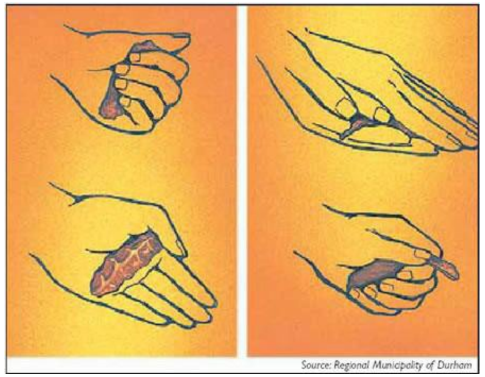
Soil structure score	Descriptor	Types and sizes of peds (soil aggregates)	Ped/aggregate rupture resistance
5	Loose Soil	Range between crumb and coarse blocky, >75% of peds/aggregates are crumbs.	Friable/firm
4	Loose	Wide size range, including very coarse blocky.	Firm/friable
3	Firm	Massive/single grain which breaks down readily to mainly crumb-medium blocky.	Firm/friable
2	Firm	Massive/single grain which breaks into crumb – coarse blocky or coarse subangular blocky.	Firm
1	Compact	Massive which breaks into mostly very coarse subangular blocky or to platy with horizontal failure planes.	Extremely firm

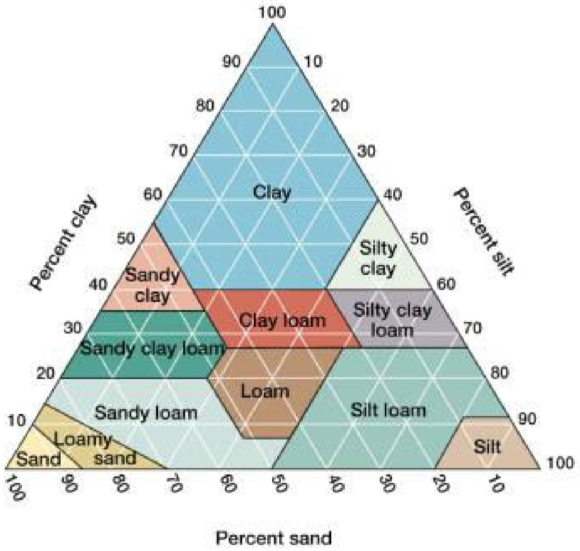
Field: Determination of Soil Texture

Feel / Spit test:

1. Place approximately 2 tablespoons of soil into your hand.
2. Add water by the drop to the soil while squeezing until the soil is moldable.
3. Use the following flow chart to determine the soil type.
4. Use the table to determine the % clay content.







Texture Type	% Clay Range
Sand	2
Loamy Sand	8
Sandy Loam	15
Sandy Silt Loam	10
Silt Loam	12
Clay Loam	30
Sandy Clay Loam	22
Silty Clay Loam	25
Clay	60
Sandy Clay	42
Silty Clay	48

Field: Soil moisture/pH

TECPEL Probe:

1. Insert the metal part of the probe into the ground embedding its metallic surface completely.

2. Wait for ten minutes and the pointer will indicate the correct value of pH.

3. Soil moisture reading, is determined by changing the setting and reading moisture value from appropriate scale.

Theta Probe:

Insert theta probe into soil, await reading displayed on screen. More accurate than TECPEL probe.

Field: Soil strength

Shear Vane

Shear strength is defined as the maximum shear stress that the soil may sustain without experiencing failure. Gives you idea of how stable a soil is under a load.

1. Insert the metal vane into the soil at a depth of 8-10 cm.

2. Ensure the dogtooth indicator is get at 0.

3. Slowly twist the torque head clockwise at a rate of 1° per second.

4. Keep twisting until soil shears, reading is displayed on dial.

<u>At each field site you must:</u>

1. Record soil moisture and pH using a TECPEL probe (takes 10 minutes to equilibrate).
2. Dig a small inspection pit approximately 10 -15cm cm deep and collect sample of soil in labelled bag from 0-10cm layer.
3. Measure depth of litter layer if present. Record depth of any obvious soil layers in 0 - 10/15cm pit.
4. Record soil structure using the description and score (degree of aggregation) using Appendix 1.
5. Record the soil texture and associated clay content using flowchart.
6. Record soil colour of all obvious soil layers within pit (this maybe just one) using Munsell charts.
7. Record soil strength (shear vane) – share between groups.
8. Record soil moisture (using probe) – share between groups.

Laboratory analysis: Soil nutrient content

Palintest:

1. Homogenise soil sample within sampling bag.

2. Following kit instructions based on the test in question. A series of steps and chemicals will be added.

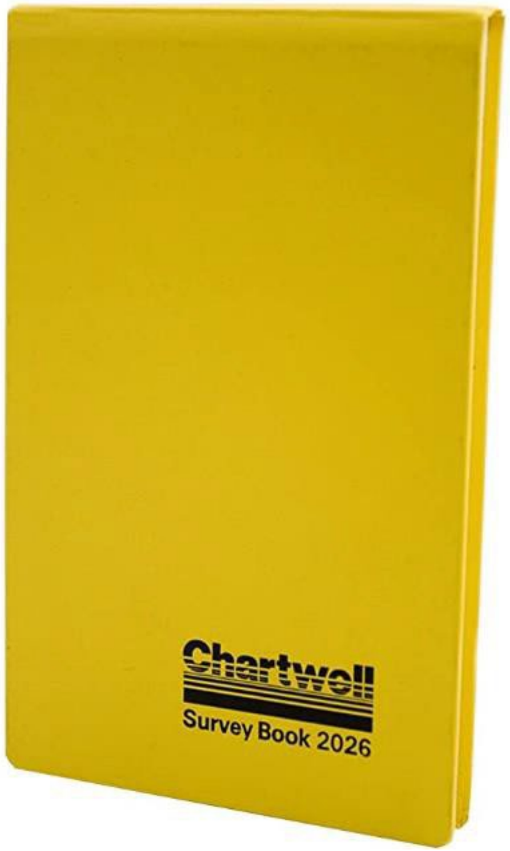
3. Reaction will result in a colour change - measured using a spectrometer (corrected for background absorbance).

4. Concentration of the component of interest can be determined from the look up table.

By the end of the session

Before the end of the session, you will have in your field notebook:

- A complete data set of soil textural, structural and profile properties for all sampling sites.
- Nutrient analysis (nitrate and phosphate) of all sampling sites.
- Collect pre-determined O.M. result table for all sites.



Combine each groups data into a class data table. This will provide replicate data for all sampling sites allow any statistics to be performed. Data will be emailed/uploaded to LEARN after the session.

Post field trip reflection

1. Create a summary table in your field notebook with data from each site.

2. Post field trip reflection:

    - State how land use has influenced the range of soil properties measured at each site.

    - What soil property or properties varied the greatest across the land use transect?

    - Hypothesise the potential impact to soil properties (i.e. O.M/soil texture/structure and nutrient content) that converting Holywell woods to arable land would cause. Use results from this fieldtrip and other literature to aid/provide evidence for your answer.

Presentation

- Review the aims and research hypotheses of the field day.
- Describe the transect and field sites – soil profiles, soil colour and texture (qualitative data). Use photos from the field.
- Briefly mention the type of soil properties measured and why they are important.
- How did land use influence soil properties. Produce graphs from the grouped data. Use statistics to analyse the data. What soil properties were significantly different across the different land use types? Why do you think any differences in soil properties exist?
- Use your findings to hypothesise the potential impact that converting Holywell woods to either arable or grassland would have on soil quality.

Further reading

1. Environmental Agency (2008) Think Soils: Soil assessment to avoid erosion and runoff. Environment Agency, Bristol, UK. https://ahdb.org.uk/thinksoils

2. A Guide to Better Soil Structure by Cranfield University: https://www.landis.org.uk/downloads/downloads/structure_brochure.pdf

3. Delelegn, Y.T. *et al.* (2017) Changes in land use alter soil quality and aggregate stability in the highlands of northern Ethiopia. Scientific Reports, 7, 13602. https://www.nature.com/articles/s41598-017-14128-y

4. Bell, M.J. *et al.* (2011) UK land-use change and its impact on SOC: 1925–2007.Global Biogeochemical Cycles, 25, GB4015 https://doi.org/10.1029/2010GB003881

5. Gregory, A.S. *et al.* (2015) A review of the impacts of degradation threats on soil properties in the UK. Soil Use and Management, 31 (S1), 1-13. https://onlinelibrary.wiley.com/doi/abs/10.1111/sum.12212

6. Hathaway-Jenkins, L.J. *et al.* (2011) A comparison of soil and water properties in organic and conventional farming systems in England, 27, 133-142. https://onlinelibrary.wiley.com/doi/full/10.1111/j.1475-2743.2011.00335.x

7. Rowell, D.L. (1994) Soil Science: Methods & Applications. Longman, London. 1st Edition.

Any questions?

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