INTRODUCTION
To master methods to capture and collect data in the field is an important part of physical geography, ecology and environmental work. Most working tasks in such line of work means that you yourself need to collect most or parts of the data you are supposed to process. Methods to measure and sampling techniques thus need to be mastered.
During this field course both simple and some more sophisticated methods using technically advanced instruments are demonstrated and the practical use of these are taught. You will yourself perform all the measurements and critically discuss results and error sources. To pass this field course you need to actively be part of all exercises as well as approved results in all tasks which could mean that maps, sketches and other material is presented and discussed in a satisfying way.

The field course contains the following exercises:
1. Excursion
2. Topographic mapping using Tachymeter
3. Levelling instrument
4. GPS
5. Orienteering
6. Landscape inventory
7. Forest inventory

Each day is split into two working passes; am 9-13, and pm 14-18. (Thursday (8-12, and 13-17).

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Observe that you will be in a Nature protected area meaning that each person has to take an ecological responsibility while working and trespassing through this area.
1. EXCURSION

The main aim with this part of the field course is to give you an introduction to the area that you will work in for the rest of the field trip. We will make a hike in the area and discuss different issues that we encounter during the afternoon, we make a number of stops and try to analyse landforms and processes that we can see evidence of, we try to put together a geomorphological picture of the region. You need reasonable clothing and most likely sturdy shoes, also bring something to take notes on and the map overview of the field area that has been provided.

2. TOPOGRAPHIC MAPPING USING TACHYMETER

Aim
The aim of this exercise is to draw a map describing the topography and other objects such as borders, big rocks etc.

Before the exercise
Read these instructions before the exercise to understand as much as possible. The Tachymeter is flexible mapping instrument where you actually start drawing the plane map in-situ.

Required materials
- Tachymeter instrument
- Measuring table
- Tripod
- Levelling rod (GDLV4)
- Sticky tape
- Transparent drafting film
- Pencil and eraser
- Note book

Principles
The Tachymeter is an instrument that is mostly used for detailed measurements in relatively small areas. One of the advantages is that you directly in the field produce a draft map of your study area.

A map is a reproduction of the real world in a certain scale, with objects inferred at high spatial precision. A sketch has less precision. Simplification and degree of generalization of a map is as we know dependant on the scale of the map.

If you want to map a region’s topography sufficient measuring points of height and horizontal position are required. In these points the relative elevation difference between the instrument height and the point is measured together with direction and distance to the point from the instrument. When sufficient points have been measured contour lines can be drawn in the map through linear interpolation. The rule is to have many points where the topography changes (where slope changes) and have less points where topography doesn’t change (e.g. flat ground or stable slope). Therefore already from the start a plan for the sampling of points should be performed. To measure too many points not adding to the precision of the map is
unnecessary but adding points where relevant (e.g. in hilly landscapes more points are required. Therefore a gain is made if you already from the start can plan where a more dense net of points is relevant and where not that many points are OK.

It is always good to make a sketch of the area from the beginning (see figure below) with the relevant objects that should be mapped as well as areas where more densely mapped points are required. Can you reach the whole study area from one measuring station or do you need to move the instrument? Discuss the scale for your map. Identify important changes in topography that would require a denser sampling. Identify and mark by sticks common points between groups (or if you need to move the measuring station.

Performance
1. Choose a measuring station from where you can see most of the area that should be mapped and additionally select a point where the transferred fix-point will be located.
2. Mount the equipment and level the measuring table.
3. Fasten the drawing film on the table using tape and rotate the table so the longer edge corresponds to the longest distance in reality. Choose the scale of your map (try to use as much as possible of the drawing film) and mark the North arrow (direction) on the map and label it with your group name and scale.
4. Now you start measuring height points. Give each point and ID number and draw the position of the point in your map. It is wise to write the elevation difference in a note book instead of on the map drawing as these later needs to be re-calculated to absolute elevation.
5. Use the GPS to add a horizontal coordinate system for your map (e.g. add coordinates for the transferred fix point. As you also have the north arrow you can now construct a coordinate grid in your map.
6. When you have all the values transfer your points to a new drawing film and together with the other groups with whom you did the exercise and finish the map with legend, symbols, coordinate grid and contour lines.
Each point’s elevation can be calculated through:

\[ H_p = (H_f - H_{\delta 1}) + H_{\delta 2} \]  

\( H_p \) = the height for the point being measured  
\( H_f \) = transferred fix point height  
\( H_{\delta 1} \) = height difference between the instrument and the transferred fix point  
\( H_{\delta 2} \) = measured height difference between the instrument and the point that are being measured

In practice all measured points are given in relative height difference (\( \Delta H \)) between the instrument height and the measured point. When the instrument height has been calculated (fix point altitude - \( \Delta H \)) the absolute altitude for all points can be calculated through Instrument height + Point \( \Delta H \).

**Presentation**

To pass this exercise you should provide a nice looking handmade map describing the topography in the study area through contour lines at 1 meter equidistance (e.g. 100, 101, 102 meter contour lines) meters). The contour lines are drawn (estimated) through a linear interpolation between the points you have measured. The map should additionally contain an X and Y coordinate grid, North arrow, legend, scale, and group numbers.
3. LEVELLING

Aim
The aim with this exercise is learn how to move a topographical reference point from a
known site to a new site and determine the elevation above sea level for this new location.
This will then be used as reference for the mapping exercise in part 2 of this guide. The
distance between the starting point (reference) and the end point (new reference point) will
also be determined.

Before starting the exercise
Read the instructions carefully, this will save time once you have started to work with the
instrument.

Equipment
- Levelling tube
- Tripod
- 4 meter levelling rod
- Compass
- Field protocol

Task description
The known reference point (127.51 m.a.s.l.) is located on the lid to the well at the Hostel
Gladan och Vråken. The exact position for placing the ruler for the first reading is on the top
of the concrete lid (please ask a teacher to indicate the position for you). Your task will now
be to move this known reference elevation to a new point close to where you will work with
the Tachymeter instrument and make a topographical map. If you have already done this
station (part 2) you did mark a reference point that you will now connect to. This reference is
very important since the topographical reference for the map will be based on this.

You should also read the distance instrument – ruler for every elevation reading you are
doing. The distance and the direction (use compass) should also be noted and plotted on
paper to calculate the euclidian distance (as the crow fly).

1. Start with a back reading by placing the instrument on a suitable spot and read the high
difference on the ruler (that should be on the reference point). Then read the distance and
direction. Note all readings in the protocol that you find at the end of this description
(annex 1).

NOTE!
To minimise the sources of error during readings it is very important that the instrument is
properly horizontal using the three levelling screws on the instrument base and that you
press the silvery fine tuning button on the instrument before each reading. Also be
consistent Also note that it is important that the ruler is hold vertically during the reading.
2. Move the ruler to the next point to which you would like to move the elevation, **but by no means the instrument should be** moved. If the instrument is moved by accident the precision of your reading will be very bad.

3. Make a forward reading on the ruler and note elevation difference, distance and direction. The elevation of the new location (where the rules is placed) could now be calculated as:
   \[ \text{New elevation} = \text{Reference elevation} + \text{Back reading (p. 1 above)} - \text{forward reading}. \]
   You do not have to make this calculation until you have reached your final destination or if you have to mark an intermediate elevation because you have to break the work session (not really recommended). If it is necessary to make a break, make sure you select a stable and easy to find location, such as a lid for a well, big stone or part of a building as reference point and make sure to describe the exact location in the column for observations in the protocol.

4. Move the instrument to a new location **and do not move the ruler**.

5. Make a new back reading on the ruler and keep going like this until you reach the final destination.

**Note that the operation has to end with a forward reading to make sense!**

**Presentation**

Hand in your filled protocol with a calculated elevation for the final reference position. Potted vectors (distance and direction readings) on millimeter paper with the Euclidian distance calculated.

**Brief description of the instrument and leveling principles**

The instrument that is used in this exercise is operating on the basic presumption that it is always placed to be absolutely horizontal. The horizontal position is achieved by operating the three leveling knobs found on the base of the instrument mount (2 in the illustration below). Horizontal position is verified using the spirit level on top of the mount of the leveling tube.
Reading in the above illustration is the centre of the hair cross reads 3.456 m as elevation difference and the distance between the two small horizontal indexes is 29.3 cm, thus the distance is 29.3 m.

The illustration below demonstrates a series of readings. First the ruler is placed over the reference point at position (A) and a reading of 2.82 m is made. The new elevation is “stored” in the instrument and the ruler is moved to position (B) where the reading 0.66 m is made. Thus the difference in elevation between positions A and B is reference height at position A + 2.82 (back reading) – 0.66 (forward reading). Assuming A = 127.51, elevation at position B will be 127.51+2.82-0.66= 129.67 m. Then the instrument is moved to a new position and a new back reading done. The process is repeated until the target position is reached.
Levelling protocol
!! For each reading write down 4 digits (m, dm, cm, and mm) e.g. 0732 !!

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4. GPS

Aim
The aim with this exercise is to learn more on how to handle a GPS receiver and also understand limitations with this technology. The GPS, Global Positioning System is frequently used for all types of field activities where positioning is important and for a geographer it is a standard component in the tool box. You will encounter this tool many times during your course work.

Equipment
- GPS-receiver
- Batteries
- Compass

Task description
The point of departure is the Hostel Gladan och Vråken. Position readings are stored in the GPS and noted on paper (as backup). At every position you note the vegetation in selected number of classes – use your own experience but it should be possible to at least classify in Cultivated areas, Grazing, Coniferous forest, Deciduous forest and Water. Try to classify according to dominating vegetation in a 50 by 50 meter square. Use number codes for vegetation classes.

Start by randomly select a compass direction after instructions from the teacher. Then take a compass bearing and start walking in the direction that you have selected randomly. Use the step counting that you have tried out to roughly determine a stop every 200 m along the path. Note the vegetation at every position and if you end up on a border between two vegetation types, make a note about this. Repeat this for about 1,5 hours and then make a turn towards the “centre” of the area by taking a direct Eastern or Western bearing on the compass. Keep this new course for about 1 km and then make a new turn towards the Hostel. For the full duration of the walk, vegetation and position should be noted every 200 m.

Presentation
The position (x- and y-coordinates) should be recorded in an Excel sheet. Make sure you do not confuse x and y directions – if you do you will end up very far from Sweden!!! The teacher will then use a Geographical Information System (GIS) to plot your samples and superpose them on an air photo for you to compare vegetation and position. Note that the intention is that you should follow a more or less straight line throughout the exercise – how well did you manage this? Can you always trust the GPS? What conditions may influence on the accuracy of the readings?
5. ORIENTEERING

Aim
To provide knowledge and skills in reading maps, navigating through maps and assessing map coordinates, in order to localize and visit a series of stations. At each station you should collect a paper slip with your group’s number and by arrival back at the hostel give the teacher the proof that you have found and visited all stations.

Equipment
- Map
- Compass
- Feet

6. LANDSCAPE INVENTORY

Aim
The aim with this task is that you should start to make use of the lectures that you have had so far on the course and relate them to something that you find in the area around the Hostel. During the allocated time for this exercise you are supposed to find something that you find worth looking at and for which you then would make a tentative explanation. It may be a landform feature, an odd change in vegetation/ecosystem or something else that you like to share with your class mates.

Equipment
- Map
- Compass
- Small spade
- Cell phone GPS if you have
- Camera or cell phone camera for documenting the site

Approach
Select a direction and take off to study the landscape, try to keep track of your position. Observe, discuss and finally select something that you find interesting. Describe the vegetation, note any irregularities, use the spade to dig a small sampling pit and try to determine the soil – is it sand, silt or clay. Are larger stones present in the soil? Does the soil seem to be well sorted or contain all grain sizes? Are slopes steep or flat? Slope direction – is it north or south facing. Make a judgement of water availability. Use your camera to take some pictures.

Presentation
One A4 page with a short description of what you have observed and one to two pictures that illustrates your observations. Try to find arguments for your explanation on the observed phenomenon.
7. FOREST INVENTORY

Introduction and aim
The aim is to, for a given forest stand:

a. describe a selected site in the forest stand, e.g. soils, topography and vegetation
b. estimate the standing volume of trees, m³ stems per hectare
c. estimate the site quality, i.e the average volume growth per year during a whole rotation period, under optimal conditions (“bonitet”).

Equipment
- Forest stand map (in this compendium)
- Measuring tape (“Måttband”)
- Tree measuring calipers for measuring tree diameter (“Klave”)
- Clinometer (for measuring tree height)
- Pins and tags to mark trees
- Spade
- Notebook and pencil

Selecting a forest site and investigation of its properties
The investigations will be done in a small site, a circle area with 10 m radius. The first step for you is to select the forest site. Forest stands in the area are shown on the map (see next page). Groups with odd numbers should find a site in the spruce stand no 112, and groups with even numbers should look in the birch stand no 110.

1. Choose a central point for your site. Use the measuring tape to measure out a circle with 10 m radius, based on the central point. Mark all the trees in the circle with tags. Describe topography, vegetation, hydrology, etc in the chosen circle and write down what you see in the notebook. Dig a pit, with a depth of about 50 cm, just big enough to be able to see the soil profile (i.e a width of about 3 dm). Describe the soil profile in the notebook. Do you see different layers? What properties do they have (colour, soil texture, are there any stones or boulders, are they rounded, do you see organic material in the soil, etc). If you have a mobile phone with camera, take a photo, remember to use the spade or some other object as scale. Then put the soil back into the pit!

Estimation of standing volume
Standing volume of is the volume of wood (stems) per area unit. To estimate standing volume you need diameter and height measurements of all trees in your circle area. Measure the diameter of the trees at breast height (defined as 1.3 m), of each tree. Measure the height of 20 random trees, and also measure the distance from you to the tree for each height measurement. Write the numbers down in the notebook. Use the formulas below to estimate volume of each tree. Use the average tree height for the trees that you have not measured. The standing volume is the sum of the volume of all trees divided with the area of the circle, and should be given in the unit m³/ha. One hectare (ha) is 100*100 m. Be careful when you convert units! Try to assess if your results are realistic!
Forest stands in the area. The first number in the number pair refers to the stand number. The second number is the age of the trees. Note that it is the actual age of the trees, not the breast height age ("brösthöjdsålder").
Volume formulas:

\[ V_{\text{spruce}} = 10^{-1.02039} \times D^{2.00128} \times (D+20,0)^{-0.47473} \times H^{2.87138} \times (H-1,3)^{-1.61803} \]

\[ V_{\text{birch}} = 10^{-0.89363} \times D^{2.23818} \times (D+20,0)^{-1.06930} \times H^{6.02015} \times (H - 1,3)^{-4.51472} \]

where  
\( V \)=volume (dm\(^3\))  
\( D \)=diameter at breast height (cm)  
\( H \)=height of tree (m), see formula below

Height formula:

\[ H = ((l \times \tan \theta) + a) \]

\( H \)= height of the tree (m)  
\( \theta \)= angle (°)  
\( l \)= distance on the ground from you to the tree (m)  
\( a \)= distance from the eye vertically to the ground (m)

Estimation of site quality (“bonitet”)

The site quality of a forest stand (“bonitet”) is the average volume growth per year during a whole rotation period, under optimal conditions. It is often used to describe a stand and compare it with others, from a wood production perspective. To estimate the site quality you need:

-“Upper height” (“övre höjd”), defined as the average height of the two trees with the largest diameter  
-breast height age, i.e. number of annual rings at breast height (“brösthöjdsålder”)  
-height development graph to derive site index  
-table for conversion between site index and site quality

Calculate the average of the heights of the two trees with the largest diameter. The breast height age (“brösthöjdsålder”) is as follows:

112 (spruce): 25  
110.1 (birch): 15

Use the graphs below to get the site index (“ståndortsindex”). Site index is the expected height (in meters) for trees at the specific site and at a defined age (100 years for spruce and 50 years for birch). For example G30 means that it is a spruce site (G=“gran”=spruce) that is expected to be 30 m high when it is 100 years old. Finally, use the conversion tables below to convert to site quality (“bonitet”).

Presentation

Prepare one PowerPoint slide with a description of the forest stand, and send to cecilia.akselsson@nateko.lu.se at least one hour before the presentation. Have the estimated standing volume (m\(^3\)/ha) and the site quality (m\(^3\)/ha/year) at hand, so that you can write it in a common table on the whiteboard at the presentation.
Growth curves for spruce (left) and birch (right) to derive site index from upper height ("Övre höjd") and breast height age ("brösthöjdsålder").

Conversion from site index to site quality: spruce

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<td>11.3</td>
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Conversion from site index to site quality: birch

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<td>Diameter, m</td>
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