Elective: Soil Survey Methodology
Exercises

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Contents

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1 Survey Specification & Planning

Objectives

- Specify a soil survey project based on client needs.

Reading

- Lecture Notes [5] §8 *Survey Specification & Planning*
- Lecture Notes §1.12 *Questions a soil survey can answer*
- Lecture Notes §3.1 *Map scale*, in particular §3.1.5 *Demand side: the decision area* and following §

Exercise

Work in groups of two or three. You will present your results to the group, as well as submit a written exercise. For all questions, **please be as specific as possible**!

Consider the comments of Dent & Young [2]:

> The practical purpose of soil survey is to enable more numerous, more accurate and more useful predictions [of land performance] to be made for specific purposes than could have been made otherwise [i.e., in the absence of location-specific information about soils]

Select a situation with which you are familiar, in which a soil survey could be useful, according to this definition. Also, select a study area.

1. Briefly describe the situation and study area. What is the size of the area?
2. List the potential users of the soil survey.
3. Give specific examples of the kind of predictions of land performance that these users could use, and what decision they would make based on these predictions.
4. Referring to §1.1.2, what kind of questions are answered?
5. How, specifically, could the soil survey improve the prediction, compared to the case where the user had no soil survey?
6. Is there any existing information that potential survey users could use to substitute for the information offered by the survey?
7. Is there some other practical way that potential survey users could themselves discover the extra information offered by the survey?
8. Referring to §3.1.5, what are the units (*Minimum and Optimum Decision Areas*) that are to be managed with soil survey information? What is their size?
9. What map scale would be necessary to represent areas as small as the MDA?

10. How many observations should support this map scale?
11. Referring to §8.13.1, what would be the cost (in person-days) of this survey?
12. Referring to §8.13.2, list some specific benefits of the survey, and attempt to **quantify** them.
13. Compute a cost-benefit ratio for the proposed survey.

2 Naming Soil Individuals with the WRB

Objectives

- Use the WRB to consistently and correctly name soil individuals (pedons) in the international standard soil classification system.
- Interpret the detailed soil individual descriptions in the ISIS format.

Reading

- Lecture Notes [5] §4.2.4 *World Reference Base as a Mapping Legend*
- Soil Brief CN7 [3] §1 and §2

References for exercise

- World Reference Base for Soil Classification [4]
- Soil Brief CN7 [3]

Exercise

There is so much technical material to cover in this exercise that the class should work as a group, divide up the work when there are many specific points, and then come together to discuss common points.

1. Read §1 and 2 of Soil Brief CN7, paying special attention to the possible soil–forming factors.
2. Referring to the list of **diagnostic horizons** in §3 of the WRB, and the study area of CN7:
   (a) Which of these horizons could **not possibly occur**?
   (b) Which are **very likely** to occur?
3. Same as the previous question, but now referring to the list of **diagnostic properties**.
4. Referring to §2 of the WRB, **prepare a simplified key** to apply to the study area of CN7.
5. Referring to soil profile CN 18:
   (a) What are its **diagnostic horizons**?
   (b) In what **Reference Soil Group** should it be classified?
   (c) Given this classification, what **interpretive statements** can you make about this soil?
   (d) Which is the first **lower-level qualifier** that should be applied to this soil?
   (e) Given this more precise classification, what **additional interpretive statements** can you make about this soil?
   (f) Do any **additional lower-level qualifiers** apply to this soil?
   (g) Do these add any **interpretive information**?
   (h) What is the final **WRB Classification** of this soil?

3 Naming Soil Individuals: lower levels (Families & Series)

Objectives

- Use the family criteria of Soil Taxonomy to consistently and correctly characterise soil individuals (pedons).
- Interpret the detailed soil individual descriptions in the ISIS format.

References for exercise

- Keys to Soil Taxonomy 8th edition [7], Chapter 17 *Family and Series Differentiae and Names*
- Soil Brief CN7 [3]

Comments

The WRB does not yet have a more detailed classification level than the second level, roughly equivalent to the Soil Taxonomy subgroup. ST goes on to defined families (and then series) as lower levels of the classification that allow more detailed soil survey interpretations. In this exercise we use ST families within the WRB. This is certainly a bit experimental at this point.

You will notice that there is common reference to Soil Taxonomy higher-level classes (Orders, Suborders, Great Groups, and Subgroups) as well as the Soil Taxonomy definition of diagnostic horizons or properties. These must be converted to more-or-less equivalent WRB classes, horizons, or properties. For example: ST *Oxisols* $\approx$ WRB *Ferralsols*, ST *argillic* horizon $\approx$ WRB *argic* horizon.

In this exercise we will not discuss soil moisture & temperature regimes.

Exercise

Do this exercise in small discussion groups of two to four. After each section we will all discuss the results together. There is a lot of detailed technical writing, and you may have to skim some of the finer points on first reading.

1. Particle-size classes
   (a) Read the section *Definition of Particle-Size Classes and Their Substitutes for Mineral Soils* on p. 295–296.
      i. What is the main reason why particle-size classes are used to name families?
      ii. In what kinds of soils are "substitute" particle size classes used? Why is this?
      iii. In what situations are "generalized" classes used? Why is this?
   (b) Read the section *Control Section for Particle-Size Classes* on p. 296.
      i. Why do you think a "control section" is defined, instead of using the whole soil?
   (c) Use the *Key to the Control Section for Particle-Size Classes* on p. 297 to determine the particle-size class control section for soil profile CN 18.
   (d) Could CN 18 have *strongly-contrasting* particle size classes in the control section?

(e) Use the *Key to Particle-Size Classes* on pp. 297–299 to determine the particle-size class for soil CN 18.

2. Mineralogy classes. In practice, a specialist in clay mineralogy should carry out this classification, but the field scientist can make an estimate.

   (a) Read the very brief introduction to the mineralogy class keys on p. 301.

   (b) From your previous studies of soil properties, give a few examples the support the statement that "The mineralogy of soils is known to be useful in making predictions about soil behavior and responses to management."

   (c) Apply the *Key to Mineralogy Classes* to soil CN 18. You will have to interpret the information about clay mineralogy in the ISIS data sheet in terms of percent abundance.

4 Naming Map Units of Soil Resource Inventories

Objectives

- Use the conventions of the USDA Soil Survey Manual [8] to consistently and correctly name soil map units according to their compositions

Reading

- Lecture Notes [5] §4.1 *Map Units classified by their categorical purity & soil pattern*, §4.6 *Names of soil map units*, §4.7 *Estimating map unit composition*
- Handouts from *Soil Systems of North Carolina* [1].

Exercise: Map Unit Names

This exercise refers to soil series names from the Atlantic coastal plain of North Carolina, USA.

Background Information

The climate is humid, with warm summers and mild winters. The major land uses are non-irrigated annual crops under high levels of management (maize, soyabeans, tobacco, groundnuts) on relatively well-drained areas, and pine plantations for pulpwood (for papermaking) on the relatively poorly-drained areas. The landscape is a broad, weakly-dissected coastal plain of Pleistocene marine sediments. Drainage is poor away from the incised streams (see Figure 6 in [1]). Almost all soils are Acrisols (finer-textured argic horizon below a coarser-textured eluvial surface horizon, low-activity clays, low base saturation). The major differences between series (as you can see from Figure 24 in [1]) are:

- groundwater level and therefore subsoil colour, and eventually organic-matter content of the surface layer
- particle-size class
- thickness of surface layer
- proportion of high-activity clays
- presence of plinthite

The probable WRB classifications of some of the series in Figure 24 in [1] are:

Series	**Classification**
Norfolk, Marlboro, Aycock, Butters	Haplic Acrisols
Orangeburg	Chromic Acrisol
Goldsboro, Exum, Duplin, Foreston	Endogleyic Acrisols
Lynchburg, Nahunta, Dunbar, Stallings	Epigleyic Acrisols
Rains, Grantham, Coxville, Woodington	Epigleyic Acrisols
Pantego	Umbri-epigleyic Acrisol
Wagram	Arenic Acrisol
Dothan	Plinthic Acrisol
Fuquay	Areni-Plinthic Acrisol

The probable Soil Taxonomy family particle-size classifications of these series are:

Series	**Family Particle-size Class**
Norfolk, Goldsboro, Lynchburg, Rains, Pantego, Orangeburg, Dothan	fine-loamy
Marlboro, Duplin, Dunbar, Coxville	fine
Aycock, Exum, Nahunta, Grantham	fine-silty
Butters, Foreston, Stallings, Woodington	coarse-loamy
Fuquay, Wagram	loamy

Note that series in *arenic* groups (i.e., Fuquay and Wagram) are classified with the *general* particle-size class "loamy". However, they are by definition (at the series level) restricted to having control sections with the "fine-loamy" particle-size class. Essentially, they are equivalent to the Dothan and Norfolk series, respectively, but with thick sandy surface layers.

Exercises

1. Referring the the *key soils* diagram:
   (a) Which soil series are *similar* to the Norfolk series?
   (b) For each similar series, what is its principal difference from the Norfolk series?
   (c) Of the series which are *dis-similar* to Norfolk, which should be considered *dis-similar limiting inclusions* within a map unit dominated by pedons of the Norfolk series?
   (d) For each limiting inclusion, what is its major limitation, with respect to Norfolk soils?
   (e) List the *non-limiting* dis-similar inclusions.
   (f) Each series should be listed somewhere in your previous answers.
2. This question relates to map units with two soil series: Norfolk and Goldsboro. As you can see from Figure 6, these occur on the same landscape, and differ in their internal drainage (Norfolk is well-drained, and Goldsboro is moderately well-drained) and hence colour of the lower subsoil.
   (a) Give the correct name to map units with the following proportions and arrangements of pedons. Assume that the pedons of the two series occur in an *predictable pattern*, i.e. with the Norfolk pedons on higher positions and the Goldsboro pedons on slightly lower positions. In the typical situation with these two series, the two series occupy contiguous, broad areas in the un-dissected plain, with the Norfolk areas closer to the drainage (and hence with a lower water table) and the Goldsboro areas farther away.

i. 100% Norfolk
ii. 90% Norfolk, 10% Goldsboro
iii. 80% Norfolk, 20% Goldsboro
iv. 70% Norfolk, 30% Goldsboro
v. 60% Norfolk, 40% Goldsboro
vi. 50% Norfolk, 50% Goldsboro
vii. 40% Norfolk, 60% Goldsboro
viii. 30% Norfolk, 70% Goldsboro
ix. 20% Norfolk, 80% Goldsboro
x. 10% Norfolk, 90% Goldsboro
xi. 100% Goldsboro

(b) In the areas away from the drainage divide, Figure 6 shows a more complicated situation. Pedons of Goldsboro, Lynchburg, Rains, and Pantego (forming a drainage sequence from moderately-well to very-poorly drained) occur in a *predictable pattern*, according to slight local undulations of the terrain. Rains is the key soil, and the others occur in *small patches* according to their relative elevation (i.e., a bit higher or lower than the average level of the plain). The soil mapper can generally see these areas without too much difficulty, but they are too small to map separately at any reasonable scale. Give the correct map unit names to these combinations:

i. 100% Rains
ii. 90% Rains, 10% Goldsboro
iii. 80% Rains, 20% Goldsboro
iv. 70% Rains, 30% Goldsboro
v. 90% Rains, 10% Lynchburg
vi. 80% Rains, 20% Lynchburg
vii. 70% Rains, 30% Lynchburg
viii. 90% Rains, 10% Pantego
ix. 80% Rains, 20% Pantego
x. 70% Rains, 30% Pantego
xi. 70% Rains, 20% Lynchburg, 10% Pantego
xii. 60% Rains, 30% Lynchburg, 10% Pantego
xiii. 70% Rains, 10% Lynchburg, 20% Pantego
xiv. 60% Rains, 20% Lynchburg, 20% Pantego
xv. 70% Rains, 20% Goldsboro, 10% Pantego
xvi. 60% Rains, 30% Goldsboro, 10% Pantego
xvii. 70% Rains, 10% Goldsboro, 20% Pantego
xviii. 60% Rains, 20% Goldsboro, 20% Pantego

(c) The Norfolk, Aycock, and Marlboro series are all kaolinitic Haplic Acrisols, and differ only in their particle-size classes, being fine-loamy, fine-silty, and fine, respectively.

- Are these similar or dis-similar series?

These soils reflect the composition of their parent marine sediments, which in turn reflect their depositional environments within the Pleistocene. If these environments were homogeneous over large areas, the soil map units are consociations of one series (e.g. essentially 100% Norfolk, 100%Aycock, or 100% Marlboro). But in some cases, the environments varied over short distances, so that pedons of two or three series occur close together, in small patches which can not be mapped without extensive boring.

Give the correct map unit names to these combinations:

i. 90% Norfolk, 10% Aycock
ii. 60% Norfolk, 40% Aycock
iii. 40% Norfolk, 60% Aycock
iv. 40% Norfolk, 40% Aycock, 20% Marlboro

(d) Now consider map units of a *general soil map* at a *small scale*, e.g. 1:250 000. Here we must include unrelated as well as related soils within one general map unit. Referring to Figure 6 for general landscape relationships, give the correct map unit names to these combinations:

First, some map units that only include the coastal plain uplands:

i. 80% Norfolk, 10% Goldsboro, 10% Lynchburg
ii. 70% Norfolk, 10% Goldsboro, 20% Lynchburg
iii. 60% Norfolk, 10% Goldsboro, 5% Lynchburg, 10% Rains, 5% Pantego

Second, some map units that include both the uplands and incised valley:

i. 80% Norfolk, 5% Wagram, 5% Gritney, 5% Johnston, 5% Bibb
ii. 70% Norfolk, 15% Wagram, 5% Gritney, 5% Johnston, 5% Bibb
iii. 40% Norfolk, 5% Goldsboro, 5% Lynchburg, 30% Rains, 5% Pantego, 5% Gritney, 5% Johnston, 5% Bibb

5 Estimating the composition of Map Units

Objectives

- Use the binomial distribution to estimate the composition of map units from a sample

Reading

- Lecture Notes [5] §4.7 *Estimating Map Unit Composition*; §6.1.2 *Description of Map Unit Composition*

Exercise: Estimating map unit composition

This exercise refers to soil series names from the Atlantic coastal plain of North Carolina, USA, as in the previous exercise.

Suppose we have made the following 20-point transects in three delinations of the same map unit:

Transect 1 Norfolk 12, Goldsboro 6, Wagram 2.

Transect 2 Norfolk 15, Goldsboro 4, Wagram 1.

Transect 3 Norfolk 18, Goldsboro 0, Wagram 2.

1. Estimate the **proportion** of each series in the *combined* map unit, that is, using all 60 data points.
2. Compute the **confidence interval** for each series, using **binomial probabilities**, at the 95%, 90% and 80% confidence levels.
3. Express your answer to the previous question in a written description of the map unit composition for the client.
4. Compute the **proportion** of each series in each transect separately. Do any of these fall outside their confidence intervals computed for the combined sample?
5. Compute the **confidence interval** for each series in each transect separately, that is, from three 20-point samples.
6. Based on the previous computation, is there any evidence to suggest that the three delineations are in fact not from the same population?

6 Soil Cartography

Objectives

- Present a soil map in an informative and visually-appealing manner

Reading

- Lecture Notes [5] §6.1.1 *Grouping map units in a legend*; §6.3.1 *Colours*

Exercise

You will be given a polygon soil map in digital form from a previous fieldwork, along with its geopedological legend. In addition, you will be given a Landsat image covering the study area, and a vector map of some cultural and natural features.

You are to make two presentation-quality soil maps, using your best judgement about design and communication with the map user

1. *Polygon boundaries* and *labels* overprinted on a light-coloured background showing the survey area, i.e. a greyscale or colour composite from the satellite image.
2. *Coloured polygons* with a *legend*. You must choose a colour scheme that groups map units in some meaningful way.

In both cases, you should show map co-ordinates, north arrow, & with both graphical and numerical scales. Show cultural and natural features to enhance location accuracy at least on the second map, and, if you think it is helpful, on the first map as well. All maps should be north-oriented.

Questions

1. What are the relative advantages of the two maps, from the user's point of view?
2. Why did you choose a certain background in the first map? In other words, why was it preferable to other choices?
3. Which grouping of map units did you use for the second map? Why is it a good choice?
4. How does the colour scheme you chose for the second map communicate something to the user?

7 Middachten Excursion

Objectives

- Gain experience in relating images and field observations of soil landscapes;
- Practice field techniques: map reading, location, augering, sand size estimation, texture estimation;
- See the limitations of image interpretation in an area with a complicated evolution;
- Enjoy the spring in the Netherlands

Reading

- Handouts on landscape evolution in the Middachten area (W. Elbersen)

Other materials

- General soil map of Gelderland 1:250 000
- Airphotos 1:17 600, 27–March–1981, Topografische Dienst, 40109–40114.
- Topographic map of the Netherlands 1:25 000, sheets 40A (Arnhem) and 40B (Doesburg)
- Satellite image

Preparation for excursion

Satellite image interpretation

1. Import the image into ILWIS, if necessary
2. Locate the study area
3. Extract a sub-image of the study area and its surroundings
4. Geo-reference the image with tiepoints, using the Rijksdriehoek (RD) coordinate system, which is over-printed as a metric grid on the Dutch topographic maps.
5. Are there any obvious "master lines" in the study area? If so, digitise them on-screen.
6. What preliminary inferences can you make about soil properties in this area? Use your knowledge of landscape evolution in the area as explained in lecture.

Airphoto image interpretationn

Work individually with the photos, but you are welcome to discuss your interpretations with the other students.

1. Do you recognize the "master lines" from the satellite image interpretation on the airphotos?

2. Identify (not yet map) the **landscapes** according to the GP approach [9].
   (a) Did you have any difficulty applying the GP concept of landscapes here?
   (b) Can you make an argument for a different division of this area in landscape(s)?
   (c) Are the landscapes (if more than one) separated by the master lines you identified earlier?
   (d) What can you infer about the soil properties of map units at this level?
3. Identify (not yet map) the **relief types** according to the GP approach.
   (a) Comment on any difficulties you had in this identification.
   (b) What can you infer about the soil properties of map units at this level?
4. Identify (not yet map) the **lithology** according to the GP approach. Here your knowledge of the Pleistocene is vital.
   (a) Comment on any difficulties you had in this identification.
   (b) What can you infer about the soil properties of map units at this level?
5. Identify (not yet map) the **landforms** according to the GP approach.
   (a) Comment on any difficulties you had in this identification.
   (b) What can you infer about the soil properties of map units at this level?
6. Make a final GP legend.
7. Using this legend, make a detailed photointerpretation of photo 40-111 (Zijpenberg-Posbank) or 40-113 (Middachten Allee). Assume the mapping scale is the same as the photo scale. This defines your mimimum delineation area and width. You may need to make some map units that are complexes because of the scale.

Excursion

See separate handout for the excursion programme. The stops will be:

1. Roozendaalseveld (heath and dunes)
2. Zijpenberg (meltwater gullies)
3. Posbank
4. Lappendeken (cover sands)
5. Middachter Bossen (transect löss – cover sands)
6. Havikkerwaard (IJssel valley terrace, contact Holocene – Pleistocene)

Post-excursion

Re-visit your image and photo interpretation in the light of what you saw in the field.

A References

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