Image Interpretation and Landscape Analysis: The Verka River Valley

NGEA03 – VT2019

Terms of reference

Background

The local government for the region of Scania has a need for improving the knowledge about current vegetation and land use in the region as well as the understanding how landscapes are evolving over time. This knowledge and understanding is necessary in order to provide better management of different landscape elements, particularly sustainable maintenance of natural reserves and protected areas in the region. Scania has a strong character of anthropogenic influence and is mainly composed of open agriculture and grazing lands intermixed with planted forest areas, mainly spruce. Deciduous forests are also very common and assumed to be the natural vegetation cover in the region before agricultural influences started to dominate during Neolithic.

Aims and output

The current proposal concerns a pilot study that aims to develop, test and improve a methodology that would be suitable for a regional inventory of the characteristics and status of vegetation and land use as well as how these have developed during the past century. The inventory should be based on air photo interpretation, involving the most recent photographs but also historical photographs to describe changes over time. A major objective with the pilot study is to develop and document a feasible methodology for such inventory and a critical review of suitable level of detail for the purpose and a cost benefit analysis in relation to other possible approaches than the proposed one (e.g. pure field inventories and satellite image interpretation). For purposes of comparison, also a SENTINEL-2 satellite image will be interpreted and results compared to the results from interpretation of the most recent aerial photographs. More specifically the pilot project should cover the following objectives and outputs:

1. A list of relevant vegetation and land use classes with appropriate descriptions and definitions (e.g. what is the definition of a forest, percentage of spruce in a forest defined as “spruce forest” as opposed to a “mixed forest”), composing a classification (or interpretation) key that may be used by others and expanded to larger areas than the pilot area. The European classification system CORINE would be a suitable starting point for this operation but the final version may be adapted to local conditions in South Sweden.
2. A map of current vegetation and land use in the pilot study area. Level of detail should if possible be on individual species level for forested areas and on functional level for open areas (e.g. cultivated, meadow, grazed). The map accuracy of the produced map should be done using appropriate data and methods. ‘
3. Assure match between the study area and the areas to the west and east by presenting a map where these has been assembled.
4. A map of current vegetation and land use in an area where no field data have been collected by the project team should be produced in order to estimate the importance of field data support. Map accuracy for this map should be compared with accuracy for the map produced in the pilot study area to estimate the importance of field data, discuss and make an estimation of field contact needed for a larger area, such as 50 by 50 kilometres.
5. A map showing important functional elements in the current landscape, such as tree, scrub and bush lines that may act as connectors between different habitats and water courses and water bodies.
6. Maps of past vegetation and land use including the oldest available remote sensing data (aerial photographs from 1940) and at least one intermediate date. Note that images from 2007 and 1999 are available in digital format but it is also possible to use printed images that would allow bridging back in time towards 1940.
7. A qualitative and quantitative analysis of changes that has occurred in the pilot area based on the above mentioned mapping exercises. Tables quantifying areal changes over time and maps showing where change has occurred should be presented at a suitable level of generalisation. Plausible reasons behind changes should be forwarded and discussed. This may involve also analysis of relevant environmental parameters such as aspect, slope and soil type.
8. Do a tentative interpretation covering the area of all 8 groups using the SENTINEL-2 satellite data that also is available. Describe, analyse and comment on differences in information content. What parts of

the interpretation key would have to be omitted if using this type of data is an important issue. Is the level of detail appropriate for use in land use management and biodiversity improvement? If there is there a cost benefit using satellite data would also be of interest.

Additionally, the costs for achieving the project should be presented in the form of work days (hours) spent on the pilot project. A mapping accuracy assessment of the present vegetation and land use map should be conducted using appropriate field data.

Results from the pilot project should be presented in a written report with relevant illustrations, tables and maps and by an oral presentation not exceeding 20 minutes. Main elements to cover are a critical review of results from the pilot study area, analysis of changes, as well as discussion of the selected methodology, its strength and weakness compared to optional methods and what improvements to the selected method that could be implemented in the light of the gained experiences during the pilot study.

Data

Data is available at `\\FILESERV\kursdata\NGEA03\Verkaan project\Varkaan Sweref99_TM\`

Directory	Brief content
All groups 1940-2007	Aerial photographs of the entire area for all groups from the missions 1940, ca 1960, 1999 and 2007
Base data	Vector maps in original scale 1:250000 (Skane) and 1:10000 (Verk_eko). NOTE, some data may be in different projections.
Digital Elevation Model/DEM2m Digital Elevation Model	DEM, 2 m resolution OsterlenDEM_rt99 (DEM of your study area, 50 m res.), SCANIA_DEM_rt99 (DEM of whole Scania)
Groupdata_SF_2016	Surface model, 2016.
Group areas	Vector map outlining the extent of the detailed study areas
Groupdata 2010	Aerial photographs of each group area 2010 mission
Groupdata 2016	Aerial photographs of each group area 2016 mission
Soils	Vector file containing the SGU soil map of the whole study area
SENTINEL2data	SENTINE2A image (10 m resolution, 4 bands), 2017.

Recording dates:
Airphoto 2016-05-12 to 05-13
Airphoto 2010-06-02 to 06-06
Airphoto 2007-06-10 to 06-15
Airphoto 1999-06-01 to 06-07
Airphoto 1960 ±5 years
Airphoto 1940 – no exact recording date available, but likely June
SENTINEL-2A 2017-05-27

Additional data can be downloaded from maps.slu.se and from ftp://download-opendata.lantmateriet.se/ (you may need to register and use a Lund University IP-number).

Set up for the project

You will work in groups of two to three persons (we encourage groups mixing nationalities and sex). Each group will be assigned a 2 x 3 km study area situated in the Verka River basin in eastern Scania. This is to be considered as a pilot study that should be designed in a way that permits up-scaling to a much larger area, potentially the whole of Scania.

Learning objectives

The immediate aim with this project is to analyse the landscape in a selected study area, particularly vegetation and land use and connect this to physical, biological and anthropogenic processes influencing landscape development. The analysis will primarily be based on data that you collect yourself, by aerial photo interpretation and fieldwork in your study area. The more general, overall aim with the project is to gain familiarity with aerial photographs and image interpretation, and an understanding of their potential, advantages, limitations and disadvantages. After this project you should be able to describe, plan, conduct and communicate the results of a similar project in, for example, a government department or consultancy company.

Practical issues

Suggestions on approach

- Develop an interpretation key common to all groups that permits a harmonised mapping of the existing vegetation by using aerial photo interpretation. The interpretation key should contain as many vegetation classes (concerning land use, vegetation cover, dominant species, etc) that are reasonable and possible using the images and methodology at hand.
- Produce a vegetation map using aerial photographs, your interpretation key and other information (soil map, available spatial data etc.).
- First field trip to improve interpretation skills (collecting training data)
- Produce a revised interpretation key and vegetation map based on field observations.
- Conduct an accuracy estimation of the final output (resulting vegetation map) using provided methods and field observations for the interpretation of the 2016 images.
- Based on experience gained during the interpretation of the 2016 images, perform land use and vegetation mapping based on interpretation of images for past dates. Changes between years should be quantified and presented in tables and using appropriate graphs. Analyse and suggest plausible explanations for detected changes.
- Roughly identify the location of your pilot area on the satellite images and make a test interpretation to determine to what level of detail it is possible to determine the classes that you have listed in your interpretation key.
- Investigate whether the above changes are associated with factors in the physical environmental such as elevation and soil type or, alternatively, are purely due to human influence.
- In a final task, in order to improve harmonisation between different groups, you will exchange study areas with another group and ”test” your interpretation key by applying it to the other group’s area.

Advice and useful hints

- Start by getting acquainted with all the material that is provided, both images and maps. Make sure that you have identified the borders of your study area correctly. Do not forget to explore map data that is available digitally, e.g. the soil map. If you are unfamiliar with GIS, ask the supervisors to provide you with some self-teaching material to get underway with the GIS software.
- An important issue that has to be determined **and** agreed upon by all groups is the minimum size of areas to include in the maps. In our case somewhere between 0.25 – 1 ha is probably about right.
- Print all background maps that you need; it is always good to have paper prints even if the bulk digitising will be on-screen.
- When you are developing the interpretation key, a test interpretation is useful to determine if a class is possible to identify in the images or not.
- Identify and delimit what you consider as obvious and take note of areas whose classification is uncertain.
- Identify and delimit areas that are homogenous even if you cannot determine which vegetation class they belong to from image information only.
- When working with the images it is wise to also indicate areas and objects (e.g. buildings, parking places, firebreaks) that are not included in the interpretation key and draw them on your map, since they may provide useful navigation support when you are in the field. See maps.slu.se.
- It may be useful to prepare a data collection form, in order to organise your work both in the field and the computer lab.

Before the first field trip

- Before the first field trip you should develop the interpretation key and do a test interpretation of your study area. Use the literature, your knowledge and imagination to map as much of your study area as possible. Take notes of areas that are difficult to identify and make sure you visit them during the field trip. A good way to do this is to print a copy of the 2016 aerial photo and use it as a background map in the field. You will have access both to paper prints of the 1997 IR-colour images (suitable for stereo-interpretation using a stereoscope) and the digital CIR images from 2010 that should be used as a reference for the actual mapping. Note that there is a difference of recording dates of the images and changes may have occurred. You should use ArcGIS to delimit different vegetation classes.

- The interpretation key could include the following elements:
  - Vegetation cover, using designations such as closed/dense, semi-dense, sparse and open
  - Vegetation type, using designations such as deciduous, coniferous, shrubs, heath etc.
  - Dominating species, such as Spruce, Pine, Oak, Birch,...
  - Land use, such as cultivated, pasture, forestry, natural vegetation
  - The interpretation key should be developed for the 2016 images, but you should keep in mind that it is wise to use a hierarchical approach permitting you to simplify the key to fit it to the other images.
  - It is intended that all groups will ultimately come to agreement on a COMMON interpretation key. Bear in mind that, if this was a real assignment at a workplace such as a county council, each group would be responsible for one part of a map sheet with the same overall key – you need to use the same criteria and terminology to be able to meet at area boundaries!

Digitizing

- Make sure to prepare and read up on how to digitize polygons with correct topology before starting to digitize your land cover/vegetation. See the documents in `\\FILESERV\kursdata\NGEA03\Verkaan project\Litterature and help\` which include information from NGEA12.

  See also the following links:
  ESRI Aligning edges to fix gaps between polygons:
  http://www.esri.com/videos/watch?videoid=1764&channelid=ArcGISVideo&isLegacy=true&title=aligning-edges-to-fix-gaps-between-polygons

  Eliminate gaps:
  https://gis.stackexchange.com/questions/82226/editing-joined-parcels-to-eliminate-gaps-in-parcel-fabric

  Topology Rules in ArcGIS: How To Fix Digitizing Errors:
  https://gisgeography.com/topology-rules-arcgis/

During field visits

- During the fieldwork you should collect two fundamentally different types of field data. The first visit is dedicated to **training data** collection, which is data that is used to increase your interpretation accuracy, since it should enable you to relate tone, colour, texture, structure, etc. in the image to the corresponding landscape units that you observe in the field, thus increasing your interpretation skills for this particular area. The second field visit is dedicated to the collection of **evaluation data** that will be used to evaluate the accuracy of your interpretation. *Evaluation data should under no circumstances be used to increase interpretation accuracy since this will violate basic statistic assumptions and make your evaluation useless.*

  - **First field trip, training data, one day:** You should select a number of places (normally about 20-40 homogenous areas) in your study area to train how to recognise different vegetation classes on the images. It is important to select at least a couple of places for each vegetation class, in order to get an idea about the natural variation inside a vegetation class. Do not forget to also visit areas that are difficult to classify using the images only. The training data will help to improve your interpretation and may even lead you to add classes that you did not realise were present in the area before the field trip.

  - **Second field trip, evaluation data, one day:** 50 locations randomly distributed within your study area. In order to satisfy statistical assumptions, it is particularly important that the locations are chosen completely at random (method described below). You MUST store the evaluation data digitally, including place ID, x and y-coordinates and vegetation class since the most practical way to obtain the necessary statistics to calculate different accuracy estimates is by overlaying the collected information from the field on the map you produced by aerial photo interpretation. You should also exchange these data with another group. There are different ways to generate (randomly) the positions of the evaluation data points:
    1. You may use the random number generator included in ARCGIS, Microsoft Excel or IDRISI
    2. See also the **Sampling Design Tool for ArcGIS** **(**https://coastalscience.noaa.gov/project/sampling-design-tool-arcgis/**)**Use any other software that you are familiar with that has this function.

3. You can even use a pocket calculator or paper table with random numbers and manually enter the x and y-coordinators you obtain into an Excel sheet for export into the GIS environment. However, this is quite labour intense and not really recommended since more efficient options are normally available.
4. Methods such as "blindly pointing with a pencil" or other pseudo-random approaches are NOT ALLOWED!

- Issue of particular importance: What size should the training and evaluation data polygons have?

- During the field work you should ensure that you collect at least the following data at each location:

  - Classification according to the interpretation key
  - Type of tree, composition of species and also estimated age class as agreed for the interpretation key
  - Shrub and field layer composition could be important to note since it may give information about soil type, nutrient content, etc.

NOTE: This is not a course in systematic botany and you are not expected to be able to describe the vegetation species composition in detail. If you are unsure of the correct (Swedish, English or Latin) name of a species that you consider important for your mapping, it is sufficient to give it a descriptive name based on its appearance or morphology, e.g. "short tree with broad pointy leaves". Online help at http://linnaeus.nrm.se/flora/welcome.html and http://www.digiflora.se/seek/webui.php

After the fieldwork

- The original (pre-training data collection) vegetation maps should be updated using the training data. This may in some cases also involve the inclusion of new classes in the interpretation key. Most often it is only a matter of changing the labels on a particular polygon, e.g. what you initially thought was spruce proves to be pine. In most cases, the borders/edges to adjacent areas remain the same and all you have to do is to rename the polygon.
- Accuracy assessment using the evaluation data points. Methods for accuracy estimation will be the subject of a lecture on the course.
- Mapping of the vegetation using the 1940 images. Note that it is probably necessary to simplify the interpretation key to confidently map the older images, since you do not have access to IR-colour images from that time and, naturally, no possibility to do any fieldwork. Logically, it is also impossible to do an accuracy assessment of this map.
- When you have finished mapping your "own" study area you should exchange areas with one of the other groups and perform a test interpretation, accuracy assessment, and include the result in the final report.

Presentation of the project:

- The presentation should consist of a written report and an oral presentation that summarises the main findings and conclusions of the project. The written report should include the following parts:
  - Short description of your methodology.
  - Classification scheme and interpretation key for the interpretation of the 2016 images; description of what modifications had to be done to adapt it to the rest of the images.
  - Maps in a suitable scale (your area – time series, and the test area from another group – only 2016).
  - Accuracy estimations for the two vegetation maps based on 2016 images (your own area and the area of the other group), with a short discussion about differences between them.
  - Areas of different vegetation classes and a description of their location in the landscape.
  - Description and interpretation of landscape changes between images and suggested reasons for changes.
  - Maintenance plans for the study area, parts to highlight as particularly important.
  - Descriptions of encountered problems, their solution, sources of errors and uncertainties in the interpretations and suggestions for improving the project results.
  - Description of current and historical land use in the detailed and larger areas. Relate changes and current use to other factors such as elevation, aspect, slope, soils and anthropogenic influence.