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FIELDWORK AND GEODATA ACQUISITION – EXPERIENCES WITH STUDENTS IN THE HIGH TATRA

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Abstract

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This paper is intended to show in an exemplary form the experiences, possibilities, difficulties, and results of Geospatial Technologies geodata acquisition in the alpine environment of High Tatra. This combined GIS, remote sensing, and cartography practice for geography students has been held almost every 2 years since 2002 on the south side of the High Tatra. The course imparts knowledge and skills about advanced methods and techniques of GIS- and remote sensing-based fieldwork. Taking into account the most important contents and competences of the study branches as stated in the local curricula, particular attention is paid to the following focal points: introduction to human- and physio-geographic settings in the investigation site, design and implementation of project-related geodatabases for the study area, GPS or device-supported sampling and integration of the results into a heterogeneous data environment of analog and digital geodata, metadata generation, and data quality issues. Selected natural, cultural/touristic, and ecological landscape topics had to be investigated by small student groups in each fieldwork year. From the beginning of planning and work assignment of a virtual project, the students had to work out time schedules and proposals and realize the project. During these about 20 years various thematic topics could be applied during this practice. Geodata acquisition at the home university (maps, satellite images, accompanying information as photographs, literature, etc.) must be planned and put into practice in the fields. During fieldwork, they have to map additional valuable information and (field)check and update their prepared database. Methods of acquiring (remote sensing) geodata as part of an applied project: primary acquisition methods, secondary acquisition methods, spatial data infrastructure, quality of geodata, metadata generation, and geodata management. After fieldwork, the students have to integrate the fieldwork data into their project analyses. Some results and problems of work are shown in this paper.

Key words: education, GIS, high mountain environment, High Tatra, landscape ecology, remote sensing.

Introduction

In short terms and from the geoscientists' point of view, fieldwork can be seen as an approach through which geographic knowledge and skills can be acquired practically in the field. Lonergan, Andresen (1988) define "the field" as any place where supervised learning can take place via first-hand experience, outside the constraints of the four-walls classroom setting. The range of fieldwork delivery methods and styles varies considerably, and the type and style of fieldwork within geography has changed extensively since the development of geospatial Technologies. The field is the major source of primary geographic information (data). Therefore, fieldwork involves observation, interpreting what is observed, and recording the relationship on the human and physical environment. Virtually, all lecturers in geography recognize the importance of fieldwork as a vital mode of teaching the subject. Therefore, the need for carefully integrated preparation of project-oriented fieldwork is stressed and the importance of debriefing and feedback after field visits is emphasized. Various suggestions for guidelines on good practice are presented. Finally, a range of future issues and problems in fieldwork is identified and discussed (Kent et al., 1997). Fieldwork in geography is conceived as a field of study that is concerned with the physical and human landscape in both urban and rural settings. Teaching must be based on observation, recording, and interpretation, and making generalizations. In most cases, fieldwork is highly complex and comprises many activities to be coordinated, which also involve a series of technical and organizational decisions. The pre-fieldwork preparation in the organization of fieldwork is crucial for success or failure. So, it could be stated at this point that data collection during fieldwork usually is particularly time-consuming and cost intensive. For this reason, the question of available optimization potential must also be considered during the preparation phase.

Geospatial Technologies have emerged as one of the most important and widely used fields for the scientists including fieldwork in last two decades. The innovations in Geospatial Technologies offer multiple opportunities for geographers and attached sciences to represent and visualize geographic process in new and innovative ways and to integrate them with ongoing environmental and economic change. To improve the efficiency of the fieldwork, in most cases, the components of Geospatial Technologies (geographic information system / GIS, remote sensing, and cartography) are used for input, storing, retrieving, manipulating, analysis, and output of geographically referenced data or geospatial data at all stages (cp. Wenshi, Zirong, 2018). The price that must be paid for this reduction in effort in the field is even more extensive training during the preparation phase.

To adequately prepare students for this demanding aspect of their professional life, the introduction to the theory and practice of fieldwork plays an essential role in the geography-related master's program. At the same time, fieldwork is widely regarded as an essential part of education and lecturers generally agree that it represents one of the most effective and enjoyable forms of teaching and learning for both staff and students. Field studies provide the opportunity to experiment with a wide variety of different modes of course delivery and have a valuable role as a vehicle for the integration of many theoretical and practical concepts taught within a geography degree. Field experience is also seen as vital for the development of students as qualified practitioners in all aspects of geography. Research in the subject is fieldwork based (Kent et al., 1997). The enhancement of Geospatial Technologies has greatly improved the potential of expeditionary fieldwork to record, analyze, and present geodata. These techniques complement the surveys and sampling that are at the heart of scientific exploration: they greatly enhance the types of fieldwork that can be carried out, reduce the amount of time needed for many tasks, and improve the quality of results (Teeuw et al., 2005; Fuller et al., 2010; Oost et al., 2011). Figure 1 shows the integrated approach of the Geospatial Technologies and fieldwork. GIS, remote sensing, and cartography can integrate individual field methods (survey, sampling, and differential global positioning system / dGPS). All methods together represent the so-called mapping units, which help to solve research questions.

Based on these considerations, this work describes the requirements to meet the needs of fieldwork in Geospatial Technologies on a master level and discusses the methods with which this training objective is to be achieved. In all master curricula at the institute for Geography and Regional Sciences, two practice courses in "Acquisition and Management of Geodata" are mandatory for the students. The basic concepts and outcomes of the second course, held regularly in the High Tatra Mountains, will be presented here. The paper also presents a further development of a description of one of the first fieldworks in the Tatras in June/July 2002 (Gspurning, Sulzer, 2004).

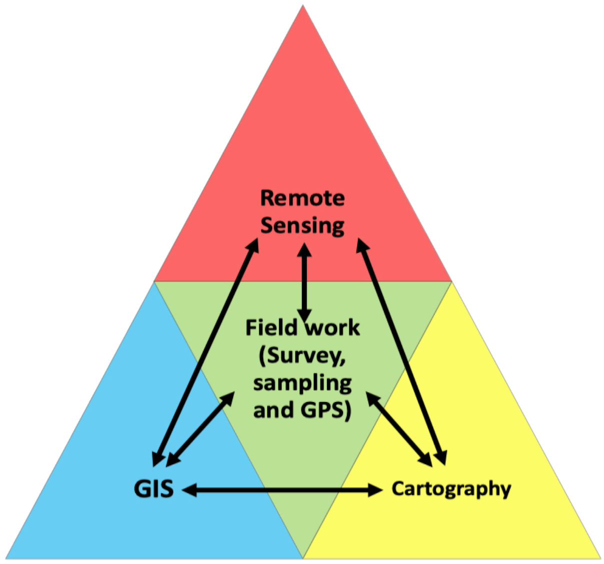

Fig. 1. Mapping unit of Geospatial Technologies (GIS – remote sensing and cartography) together with fieldwork (own drawing).

Fundamental requirements of fieldwork in Geospatial Technologies

The central element of geographic fieldwork is data acquisition, which in turn is divided into the sub-areas of data modeling, acquisition technology, and acquisition methodology or evaluation. To ensure the smoothest possible workflow, these aspects must be designed and integrated accordingly in each of the following phases of the fieldwork:

1. Preparation stage: This is the stage before going out into the field. In this stage, one makes preparation for the field study as follows:
   - formulating the topic and objectives of study;
   - primary and secondary date acquisition;
   - designing the methodology;
   - selecting the equipment and mapping tools to use; and
   - making other preparations such as organizing transport, planning routes and time for fieldwork.
2. Actual fieldwork stage: This is the stage when one is in the field gathering information using the various methods and techniques such as observing, sketching, mapping, taking notes and photographs, field check, etc.
3. Follow-up stage: This is the stage when one is back from the field. In the follow-up stage, the collected data and information will be integrated in GIS or image processing software for further analyses.

As already mentioned, fieldwork means collection of entity's characteristics, values, or measurements taken from the real world and – according to the requirements for digital machining –preparation for further processing, analysis, and visualization. This can be done by acquiring numbers, words, measurements, observations, or even data in the form of just narrative descriptions of things; so, data can be quantitative or qualitative in nature. From this point of view, too, data modeling and data collection must be exercised very carefully to provide serious data for the following analyses, interpretations, and policy decisions. Hence, if the data are inaccurate and inadequate, the whole analysis may be biased or faulty and the decisions taken are misleading.

Due to the specific topic assigned by the teachers for each course, the students' program typically includes the collection and integration of secondary data in addition to primary data. For this reason, the quality of the final product heavily depends on the metadata to understand the quality and specifics of each dataset. Collecting data in the field, it will be confident of the who, what, where, why, and when of a data set. You should be aware of the advantages and the disadvantages of your methods, and can quantify the accuracy, precision, and potential errors associated with the equipment you are using (cf. van Emmerich, 2015).

By referring to the basic tasks of GIS (collection, management, manipulation, analysis, and visualization of geodata), it quickly becomes clear that the understanding of a specific geographic problem and the competence to (factually and methodologically) correctly collect and parameterize the data required for the solution must be given at least as much importance as the actual data analysis. It is not about teaching these steps in the sense of a demonstration or the reproduction of the presented techniques, but rather about the most extensive independent working out of problem solutions in the broadest sense of the word against the background of arbitrary questions in the context of a holistic geography. It goes without saying that the approaches propagated in this way are highly integrative and therefore naturally not only limited to covering the core areas of geographic technologies, but also attempt to integrate other technologies (GPS, terrestrial laser scanner / TLS, thermography, Geo radar, etc.) or build bridges to other disciplines.

Moreover, many published remote sensing project reports have a strong emphasis on image processing techniques with very little detail regarding the methods used for collecting data and information in the field (McCoy, 2005). Since most remote sensing projects require some amount of fieldwork, there should be significant benefits to a systematic approach to planning the field portion of the project. Certainly, the final product will be more reliable and defensible if the fieldwork and the use of reference materials is planned and executed properly. Field survey is essential to identify the features of interest in a study area, to record the locations of features for image classification (i.e., creation of land use/landcover classification), and to obtain independent reference data to test the accuracy of resulting classifications which should not be underestimated. Fieldwork in remote sensing is important in order not to be limited to satellite or aerial photographs, but to be able to record and validate data directly in the field. Comparisons can thus be made on site, which means that an improved final result of the remote sensing image evaluation can be achieved (McCoy, 2005). To be able to achieve an optimal result of a remote sensing project, the combination of fieldwork and remote sensing (reference materials such as aerial or satellite images, maps, etc.) is an indispensable and important part of the project planning (McCoy, 2005). The subject of fieldwork as a combined approach of fieldwork and remote sensing and the associated methods can be exemplified as follows:

Classification is the assignment of a pixel to an arbitrary class according to the value of the pixel. However, a pixel can only be added to a class if it meets certain criteria. But what does a classification have to do with fieldwork? It can often happen that certain class from the remote sensing image cannot be precisely delimited. In this case, ground truthing (field inspection) is essential. The procedure is to first sketch the class boundaries as polygons in the remote sensing images. This should give a rough overview – changes can still be made directly in the field. This is followed by the ground truthing, that is, it is classified directly in the terrain/field. All polygons that cannot be clearly defined must be defined. This means that polygon boundaries can be edited, added, or deleted and finally, the assignment of the classes takes place. Another option would be to use a field PC or tablet. A lot of time can be saved with these, since the polygons are already available and can be adjusted, edited, or changed as desired during the field inspection. In addition, the integrated GPS helps to keep your bearings on the terrain.

Methodological framework of the fieldwork in the High Tatra Mountains

Field courses, field camps, field trips, field labs, and field investigations have been part of the foundation for careers in environmental sciences, ecology, geology, and archaeology. Scientists in these disciplines claim that field experiences help students develop a feel for Earth processes, a sense of scale, an eye for significant features, and an ability to integrate fragmentary information of different types from different localities, to reason spatially, to visualize changes and to analyze the quality and certainty of observational data supporting geoscience theories (Manduca, Carpenter, 2006). Most research on school-based learning has focused on learning that occurs in a classroom, laboratory, library, or computer room. But in earth science, ecology, and environmental science, a different venue is important: field-based learning. In these disciplines, working "in the field" means going outside, making observations, and taking samples of objects, structures, processes, and phenomena, using the human senses and instrumental sensors. The features of interest include rock formations, soil, weather, plants, animals, landforms, bodies of water, the interrelations among these, and the processes by which they change through time or vary across space, either naturally or due to anthropogenic influences (Science Education Resource Center at Carleton College, 2023).

Course details of "Acquisition and Management of Geodata 1" (winter semester)

Table 1 provides specific teaching content of the course AMGD-1 that is offered at the beginning of the master's degree in winter semester.

Goal of Acquisition and Management of Geodata 1 (AMGD-1) is to bring all students of the various fields of master study (Human Geography, Physical geography, Geospatial Technologies) up to a same knowledge level, so that they are "fit" for fieldwork (AMGD-2) in the following summer semester. The course AMGD-1 imparts knowledge and skills about advanced methods and techniques of GIS- and remote sensing-based fieldwork.

Particular attention is paid to the following content-related focal points:

- introduction to acquisition and management of geodata, design and implementation of project-related geodatabases, metadata generation, data quality issues;
- acquisition methods of (remote sensing) geodata in the field (geo-referencing, training area selection, data integration and management, etc.);
- DGPS or device-based sampling and integration of geodata;
- basics and application of «Structure from Motion» technology including embedding for unmanned aerial vehicle (UAV) data analysis; and
- basics of lidar technology and applications/analysis of TLS data.

Issuing the information for the fieldwork, grouping, task: written elaboration for planning the fieldwork (possibly using a checklist), preparing the mapping bases for the field.

Table 1. Course details AMGD-1 in winter semester.

Content	The course provides knowledge and skills on advanced methods and techniques of GIS- and remote sensing-based fieldwork, with a special focus on the following main subject areas: dGPS-based sampling and result integration into a heterogeneous data environment consisting of analog and digital spatial data, metadata generation, and issues of data quality. Principles and fieldwork with TLS data. Data capture of remotely sensed geodata: acquisition of ground truth (classification signatures) and integration/ evaluation in an image processing software; image data acquisition for Structure from Motion and production of a 3D model including orthophotographs and surface models.
Previous knowledge expected	Basics in remote sensing and photogrammetry (15 European Credit Transfer System / ECTS). Basics in GIS (15 ECTS). Basics in cartography (6 ECTS). Basics in GPS (3 ECTS). Basics in human and physical geography (12 ECTS).
Objective (expected results of study and acquired competences)	After successful completion of the course, students should be able to do the following things: understand and apply the basic principles of spatial data acquisition, data integration and management, and evaluation. Working independently and within a defined time frame on a given topic from the theory or application area of GIS and remote sensing, critically evaluating international specialist literature, proposing own solutions, presenting and discussing the work results, and reflecting on criticism. Knowledge of different methods of collecting geodata, quality criteria, and implementation of applied projects.

Notes: AMGD-1 ‑ Acquisition and Management of Geodata 1; TLS ‑ terrestrial laser scanning.

Table 2. Course details AMGD-2 in summer semester.

Content	The course provides knowledge and skills on advanced methods and techniques of GIS- and remote sensing-based data acquisition, with a special focus on the following main subject areas: introduction to the investigation area, design and implementation of project-based spatial databases for the study area (in foreign countries), GPS- or device-based sampling and result integration into a heterogeneous data environment consisting of analog and digital spatial data, metadata generation, issues of data quality. Data acquisition of (remotely sensed) geodata within an applied (fieldwork-based) project: primary data capture – secondary data capture – geodata structure in different countries – quality of geodata – metadata – data integration and management
Previous knowledge expected	Acquisition and management of geodata 1.
Objective (expected results of study and acquired competences)	After successful completion of the course, students should be able to: investigate problem-relevant information about the study area in teams supervised by a team coordinator, discuss and compile project-related data models, review different device-based methods for spatial data sampling, perform integration of the recorded data correctly into existing analog and digital data collections, document the spatial data, assess the data quality, and present the results. The students will have advanced skills in different acquisition methods of geodata, quality criteria, and realization of an applied project.
Objective (expected results of study and acquired competences)	After successful completion of the course, students should be able to do the following things: understand and apply the basic principles of spatial data acquisition, data integration and management, and evaluation. Working independently and within a defined time frame on a given topic from the theory or application area of GIS and remote sensing, critically evaluating international specialist literature, proposing own solutions, presenting and discussing the work results, and reflecting on criticism. Knowledge of different methods of collecting geodata, quality criteria, and implementation of applied projects.

Note: AMGD-2 ‑ Acquisition and Management of Geodata 2.

Table 3. GIS and remote sensing requirements for AMGD-2.

GIS AMGD-2 campaign requirements	Remote sensing AMGD-2 campaign requirements
1) (Based on the contents of AMGD-1) Specification of a rough research goal with special consideration of the development of problem-specific spatial databases 2) Specification of research questions and the intended results based on the study of relevant sources (this step usually takes place in small groups for the purpose of broader opinion formation) 3) Summary and homogenization of individual approaches 4) Study of the data sources considered for the problem solution and their suitability 5) Development of a data model (real-world model, object model, and data model) and an acquisition strategy based on it (including the most precise schedule possible at this stage); depending on the selected topics, this step may include comprehensive tasks in the fields of TLS and dGPS 6) Preparation of fieldwork (analog and digital work aids, applications, improvement of the schedule, etc.) 7) Fieldwork (independent processing of the work plan with the supporting feedback of the teachers) 8) Data acquisition 9) Development of an appropriate sample of test sites (in case of extensive areas of investigation) 10) Ongoing critical review of all elements of the acquisition process 11) Visualization of the collected geodata 12) Final discussion of the campaign and reporting	1) Basic development • Dealing with the relevant literature • Which time periods and which data (sentinel) are available for this? • Creation of an object-type catalog for land use /land cover LU/LC (settlement area/places and high mountains) • How can these be spatially recorded and quantified? • Structure of a spectral «signature data set» of the LU/LC objects 2) Preparation (data sets) and planning of fieldwork • Preparation of the mapping bases (which bases, in what form, etc.) • Clarifying the required infrastructure (hardware) • Estimation/classification of the detection areas (will be specified!) • Development of a timeline 3) Implementation of the field campaign • Mapping of the objects on site • GPS-supported localization/recording of the «objects» 4) Data integration and evaluation • Creation of a database of the collected data • Integration of the mapping/data sets in the «signature editor» • Implementation of the LU classification and evaluation 5) Presentation, geovisualization, and documentation

Table 4. Description of the thematic layers according to the Environmental System Research Institute (ESRI) data model.

Layer	Building	Images	Basemap
Map use:	Floor plan representation of the buildings	Illustration of buildings	Map background, orientation
Data source:	Coordination group	Own images	ESRI street map
Representation:	Multi-polygons with attributes extensive	Multi-points with pop-ups and path to the original images	Vector map
Spatial relationships:	1:n	One building can have many images, but at least one	Does not share geometry with the other layers
Map scale:	Arbitrary scalable	Arbitrary scalable	Arbitrary scalable
Symbology and annotation:	Color-filled polygons, classified by relevant characteristics, 2D	Points and image display within a pop-up window with details, 2D	Classified geovisualization of streets and relevant topographic features, 2D

Course details of "Acquisition and Management of Geodata 2" (summer semester)

Table 2 provides specific teaching content of the course that will be offered in the following summer semester after the AMGD 1 course in winter semester.

Table 3 lists the specific field campaign requirements in the areas of GIS and remote sensing for the AMGD-2 course.

Results (examples)

Figure 2 shows an example of the distribution and assignment of the investigation areas for the students.

The following paragraph tries to exemplify the individual steps and the results of the GIS part of the fieldwork, which was conducted for Group A from 06/17/2018 to 06/20/2018 and for Group B from 06/19/2018 to 06/22/2018 in the High Tatras (Slovakia). At the end, an example of feedback from students can also be found.

The goal for the students was to understand not only the current (i.e., 2018) situation, with a special focus on the tourist infrastructure, landscape changes, but also changes in the settlement structure. In this report, the focus is on settlement structures and tourist infrastructure. In this, the building structures were recorded, mapped, and entered into a database. For this purpose, not only the external features such as the shape of the roof and the roof material, but also the building material were relevant. In addition, attributes that indicate a tourist infrastructure were noted.

Table 4 shows the description of the thematic layers according to the Environmental System Research Institute (ESRI) data model for the used layers (building, images and basemap).

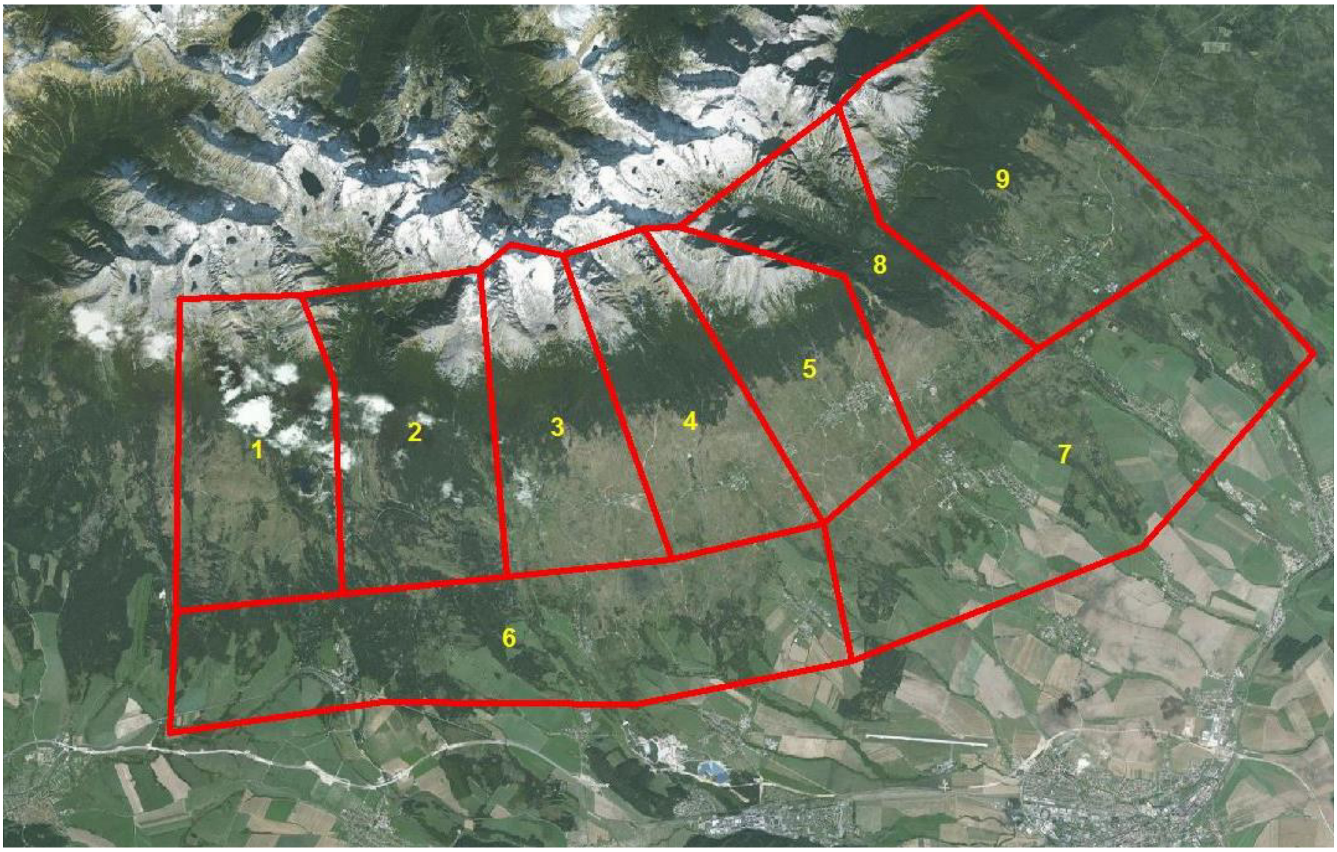

Fig. 2. An example of the distribution of the investigation areas for the students. In general, about six to eight students will work in the field during Monday and Friday.

Fig. 3. Number of floors (left) and state of the construction (right) in Nova Lesna.

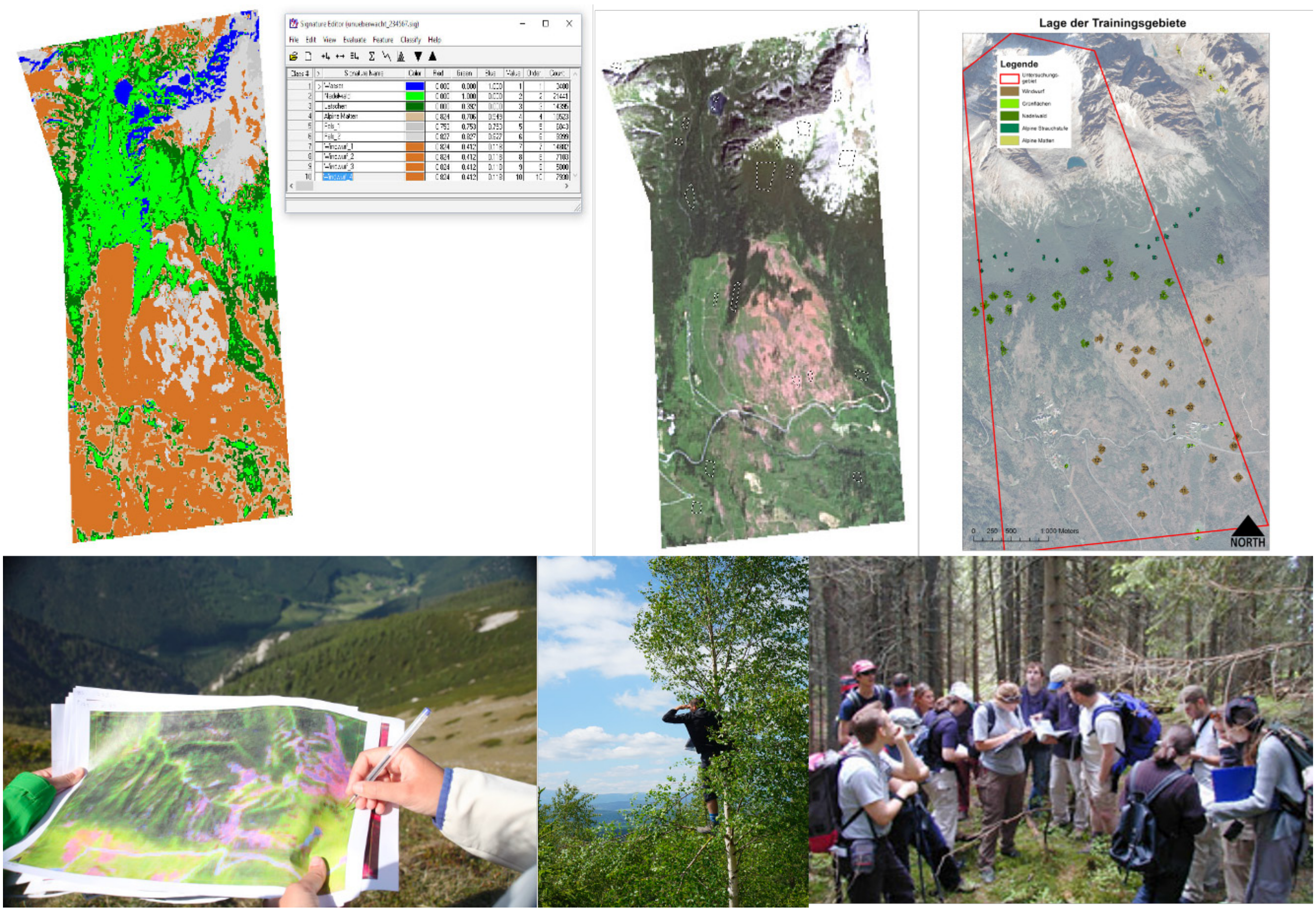

Fig. 4. Remote Sensing bases LC/LU classification and fieldwork.

Fig. 5. Tree sampling and pest infestation classification with bark beetle.

Figures 3 and 4 in turn document examples of the representation of the floors and state of the construction in Nova Lesna, while Figure 5 shows tree sampling and pest infestation classification with bark beetle.

In this course, we were able to independently prepare, process, and post-process a project in GIS and remote sensing, and thus apply learned theory from previous courses. By comparing the original plan of the fieldwork and finally the procedure of the fieldwork, we could check our group internal management and gain new competences, so this exercise was very helpful. In both groups, there were unforeseen events that significantly affected the fieldwork. To give some examples:

- numerous large, even sometimes nasty, dogs that made picking up attributes difficult;
- contact with local police due to numerous calls from the public and concerns about our work in the field;
- cancelled train connections or denied access to certain buildings; and
- technical or organizational problems with photos.

It is important to take a solution-oriented approach to such challenges, and it often becomes necessary to make effective decisions quickly and thus react to unexpected problems (e.g., recording data remotely, supplementing via secondary sources if necessary, planning alternate routes, gaining general flexibility in fieldwork, etc.). Not only at the initial presentation of the interim report, but also at meetings of the course group on each evening of fieldwork, we were able to present and discuss our work steps and and discuss our results. Here, exchange with other course participants and course leaders was largely helpful. Preparation for the fieldwork worked very well in our group, as most of the members already had experience in fieldwork as well as in the acquisition and management of geodata

Conclusion

The paper presented only views case studies of various topics of fieldwork in the High Tatras and the importance of student education in designing fieldwork, application of Geospatial Technologies, and sampling strategies at the beginning of the master studies.

Fieldwork is often a special topic for master study or PhD. Students often do not hear something about how to plan, to do fieldwork, and which possibilities they have (in the field of Geospatial Technologies). Doing this in a foreign country (without language knowledge, without knowledge about the investigation area, without knowledge of the specific data infrastructure) will improve the flexibility. To design a project and work from idea to fieldwork and data integration and analyses will make the studies fit for further detailed focused studies and for the future professional environment.

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