

## Chapter 2

# Methods and Materials

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**Abstract** Landscape field mapping at a scale of 1:25,000 was the basic method of surveying the study area in the 1980s. Also the extent of the glaciers and their marginal zones as well as the sea coastline was mapped. The interpretation of aerial photographs, including the infrared ones, as well as the analysis of satellite data were combined with the results of field investigations. The following datasets were used in the manual delineation of the extent of each glacier in the chosen years: (1) three sheets of a topographic map 1:25,000, edited by the Polish Academy of Sciences in 1987, (2) a topographic map sheet at a scale of 1:100,000, edited by the Norwegian Polar Institute in 2007, (3) ASTER data with 15-m spatial resolution provided by NASA's Earth Observing System (EOS), and distributed by the Land Processes Distributed Active Archive Center (LPDAAC), and (4) SPOT 5 Orthophoto with 5-m spatial resolution, acquired on September 1st, 2008, provided by the IPY SPIRIT project. The maps were scanned and georeferenced to a common datum and projection. Changes in glacier surface elevation were estimated using digital elevation models. In the early 1980s, extensive vegetation research was carried out, using the Braun-Blanquet phytosociological method and a detailed vegetation map at a 1:25,000 scale was constructed. To evaluate the speed and direction of possible vegetation changes in the area, the aforementioned research was repeated in 2008. In both studies data were supported by photographs of the main vegetation types and their changes.

**Keywords** Landscape mapping · Phytosociological mapping · Remote sensing and GIS methods · Topographic maps · Aerial photographs · Satellite data

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## 2.1 Landscape Research

### Wiesław Ziaja and Justyna Dudek

Complex landscape field mapping at a scale of 1:25,000 was the basic method of surveying the study area in the 1980s. A total of 1514 small basic landscape units (so-called geocomplexes of the *uroczysko* range) were mapped across an area of approximately 94 km<sup>2</sup>. An old Norwegian topographic map at a scale of 1:100,000 (Sørkapp sheet), current for 1936 and enlarged fourfold, was used as a base map. Each individual landscape unit was drawn on the map, numbered, and described on a special separate form. The demarcation criteria consisted of spatial changes in environmental and landscape features. The following characteristics were analyzed: elevation, slope gradient and exposure, lithostratigraphy, tectonics (dip of the rock strata), Quaternary deposits (genesis, granulation, thickness), morphogenesis, microrelief, geomorphic processes, mesoclimate (based on exposure, shadowing, and persistence of snow patches), and bodies of water and vegetation (density and composition, division into vascular plants, mosses, and lichens). The mapping covered virtually all of the area that had not been covered by glaciers during the Holocene in western Sørkapp Land. The landscape units were grouped into several dozen types, which made it possible to create detailed maps of the landscape structure of the area (Czeppe and Ziaja 1985; Kuczek and Ziaja 1990; Ziaja 1991, 1992). This structure had not changed by 2008. However, certain changes within some of the landscape types were observed in 2008.

In addition, the extent of glaciers and their marginal zones as well as the sea coastline were mapped via a traditional method (using a Paulin altimeter) in the 1980s, and using more modern methods (GPS 12 Garmin) in 2008.

The interpretation of aerial photographs obtained from the Norsk Polarinstitut, especially black-and-white photographs from 1961 and infrared photographs from 1990, as well as the analysis of satellite data were combined with the results of field investigations in a very effective way.

The analysis of glacier retreat since the 1980s was divided into two parts. The first part addressed changes in the glaciers' surface area in 1984, 1990, 2004, and 2007. In the second part, changes in the glaciers' surface elevation from 1990 to 2008 were inferred from two digital elevation models (see Maps in Chap. 4).

The following datasets were used in the manual delineation of the extent of each glacier:

1. Three sheets of a topographic map (Hornsund, Gásbreen, and Bungebreen) at a scale of 1:25,000, edited by the Polish Academy of Sciences in 1987. The map was compiled photogrammetrically on the basis of vertical aerial photographs at a scale of 1:50,000 (taken in summer 1961) and geodetic measurements carried out during the Sixth Spitsbergen Expedition of the Academy during the 1983 and 1984 summer seasons.

2. A topographic map sheet (C13 Sørkapp) at a scale of 1:100,000, edited by the Norwegian Polar Institute in 2007. The map illustrates the extent of each glacier and provides contours at 50-m intervals. The part of the map with the study area was created based on vertical aerial photographs at a scale of 1:50,000 (taken in summer 1990).
3. ASTER data with 15-m spatial resolution provided by NASA's Earth Observing System (EOS), and distributed by the Land Processes Distributed Active Archive Center (LPDAAC): two consecutive scenes acquired on August 7th, 2004, and two consecutive scenes acquired on August 14th, 2007. All ASTER bands used in the study were orthorectified and projected to WGS84, UTM zone 33 north projection.
4. SPOT 5 Orthophoto with 5-m spatial resolution, acquired on September 1st, 2008. The data were provided by the IPY SPIRIT (International Polar Year SPOT5 stereoscopic survey of Polar Ice: Reference Images and Topographies) project (Korona et al. 2009). The mapping of glaciers was difficult in 2008 due to thick snow cover; therefore, only the frontal sections of tidewater glaciers and Bungebreen were updated using this dataset.

The maps were scanned and georeferenced to a common datum and projection (WGS84, UTM zone 33 north) using the four corners and 50 evenly distributed points for each map sheet edited by the Polish Academy of Sciences and about 100 points for the map edited by the Norwegian Polar Institute. The extent of each glacier based on Polish maps was validated and corrected using photographs taken in the field during Jagiellonian University expeditions in 1983 and 1984.

Changes in glacier surface elevation were estimated using two digital elevation models (DEMs). The first was a modern DEM with 20-m resolution compiled by the Norwegian Polar Institute from vertical aerial photographs at a scale of 1:50,000 taken in the summer 1990. In order to compare it to the second DEM, the dataset for 1990 was resampled to 40-m resolution. The first DEM was used as a reference dataset. The second DEM, with 40-m pixel size, was provided by the IPY SPIRIT project. It was generated from a cloud-free high-resolution SPOT 5 HRS image pair acquired on September 1st, 2008. The DEM extraction was performed by the French Institut Géographique National (IGN) following an automatic processing method, including manual intervention and interactive checks against ground-based measurements (Korona et al. 2009). The optical contrast of the images was mostly satisfactory, although in some parts, image matching had failed. Unmatched areas were masked and marked as "error in data". The SPIRIT DEM was co-registered using an analytical solution developed by Nuth and Kääb (2011), based on the cosinusoidal relationship between elevation differences and elevation derivatives of the slope and aspect. The method permitted minimizing a three-dimensional shift vector between two DEMs.

Changes in glacier elevation over the period 1990–2008 were estimated simply by subtracting the SPIRIT DEM from the reference DEM. The resulting values in the new raster indicated the difference in elevation at each pixel.

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## 2.2 Botanical Research

### Michał Węgrzyn, Maja Lisowska, Maria Olech and Piotr Osyczka

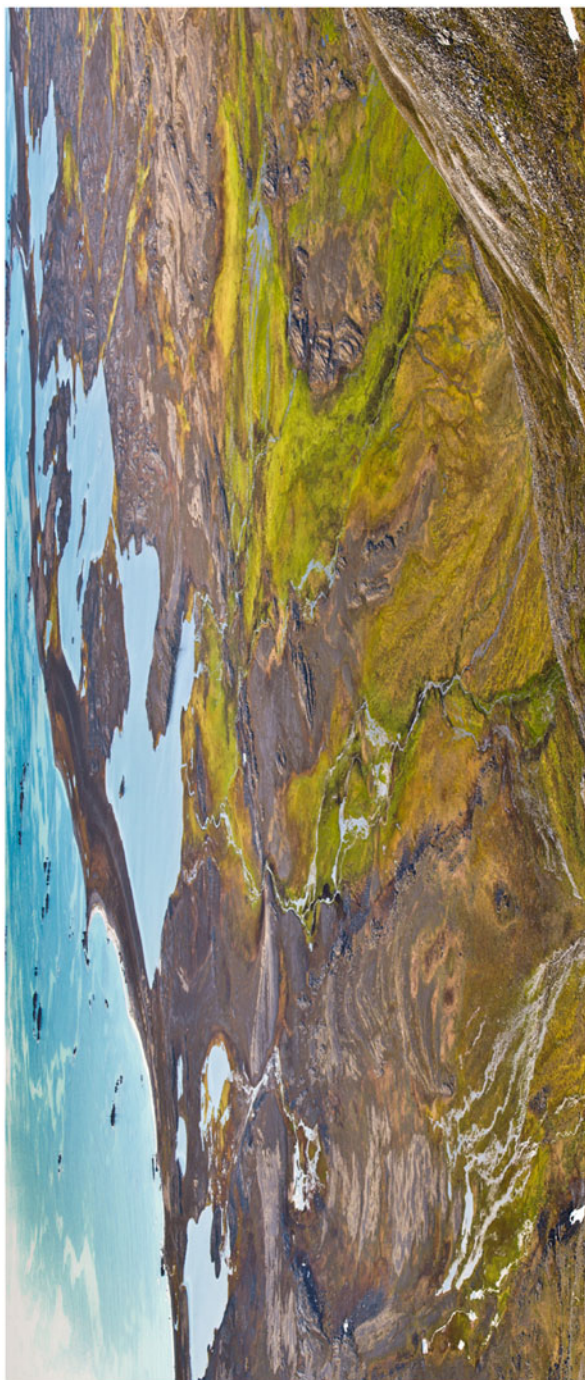
Western Sørkapp Land is diverse in terms of habitat conditions such as: topography, bedrock, hydrological and edaphic relationships, and microclimate. Lichens and bryophytes are predominant along with a few flowering plants, creating a complex mosaic of vegetation (Fig. 2.1). Therefore, the term plant community used herein applies both to vascular plants and cryptogamic organisms, that is, lichens and bryophytes.

During the 1982 and 1985 summer seasons, extensive vegetation research was carried out in northwest Sørkapp Land. The study area included marine terraces along the northern and western shores of Sørkapp Land, from the Lisbetelva river to the Vinda river, Hohenlohefjellet (614 m), as well as the western slopes of Sergeijevfjellet and Lidfjellet (Dubiel and Olech 1990).

Phytosociological research in the years 1982–1985 led to the identification of 28 vegetation units in the study area. The basis for the identification was 285 phytosociological relevés, performed according to the Braun-Blanquet (1964) method. Photographs were taken at different locations in order to obtain a full picture of the variety of vegetation. Complete phytosociological tables were created for 26 plant communities (Dubiel and Olech 1990), which were selected on the basis of their floristic characteristics. In some cases, the presence of dominant species strongly influencing the physiognomy of patches was considered more important. A short description of the habitat as well as comments on the distribution were added to the descriptions of vegetation. Names of differential species and their ecological scale were given for each community. Community names derive from the names of differential species, which were often dominant species. No new names of associations were created, as that would be premature, given the current state of knowledge of the diversity of the whole vegetation in Spitsbergen and the Arctic.

Next, field mapping was carried out. The arrangement of plant communities identified during phytosociological research was marked on a 1:25,000 map (Dubiel and Olech 1991). Vegetation units were marked on the map for four primary categories: (a) homogeneous plant communities occupying large areas; (b) examples of clear dominance of one community over others within a particular mosaic; (c) arrangement of two or three neighboring communities creating a mosaic; (d) large areas of transition between two or more communities.

In 2008 phytosociological research was repeated in the same plant communities, which had been identified in the 1980s (Dubiel and Olech 1990). The Braun-Blanquet



**Fig. 2.1** Central part of the Hornsundneset terraced coastal plain built of Early Carboniferous sandstones, siltstones, and shales. A general view of the tundra vegetation and lakes (dammed by isostatically raised coastal ridges) from the slopes of Sergejefjellet, facing WNW. *Photo M. Węgrzyn, 2008*

(1964) method was used once again. In phytosociological relevés, all groups of plants and fungi contributing to the composition of communities were included. The repetition of the phytosociological study in the same geographic area provided an accurate record of the state of the vegetation, and also allowed evaluating the speed and direction of changes. As was the case with earlier research (Dubiel and Olech 1990), the exact syntaxonomic position of certain plant communities was not precisely specified, inasmuch as it was not the aim of the research. However, the synonyms of the names of plants and fungi were updated.

In order to obtain data about changes in the size of plant communities, vegetation mapping was repeated on a 1:25,000 scale map. Field GPS devices containing a rectified version of the vegetation map from the 1980s, with areas of different vegetation units marked, were employed during the fieldwork. In many cases, the location of certain geomorphological elements such as streams, rivers, lakes, slopes, and shorelines, all of which create natural boundaries for plant communities, was adjusted as well.

Both vegetation maps were substantially improved. Relief was added to the maps, which created an opportunity for easier interpretation of the extent of each plant community. The final versions of both maps were prepared on the same scale of 1:50,000 in order to show vegetation changes more accurately (see Maps in Chap. 4).

Vegetation maps of the same geographic area created for different periods of time are the best way to show spatial changes in vegetation.

## References

- Braun-Blanquet J (1964) *Pflanzensoziologie: Grundzüge der Vegetationskunde*. 3. Auflage. Springer, New York, 865 p
- Czeppe Z, Ziaja W (1985) Structure of the geographical environment of the north-western Sörkappland (Spitsbergen). *Zeszyty Naukowe Uniwersytetu Jagiellońskiego, Prace Geograficzne* 63:19–32
- Dubiel E, Olech M (1990) Plant Communities of NW Sörkapp Land (Spitsbergen). *Zeszyty Naukowe Uniwersytetu Jagiellońskiego, Prace Botaniczne* 21:35–74
- Dubiel E, Olech M (1991) Phytosociological map of NW Sörkapp Land (Spitsbergen). *Zeszyty Naukowe Uniwersytetu Jagiellońskiego, Prace Botaniczne* 22:47–54
- Korona J, Berthier E, Bernard M, Remy F, Thouvenot E (2009) SPIRIT. SPOT 5 stereoscopic survey of Polar Ice: reference images and topographies during the fourth international polar year (2007–2009). *ISPRS Journal of Photogrammetry and Remote Sensing* 64:204–212
- Kuczek M, Ziaja W (1990) The structure of the geographical environment of the area between two glaciers: Vitkovskibreen and Olsokbreen. *Zeszyty Naukowe Uniwersytetu Jagiellońskiego, Prace Geograficzne* 81:31–56
- Nuth C, Kääb A (2011) Co-registration and bias corrections of satellite elevation data sets for quantifying glacier thickness change. *Cryosphere* 5:271–290
- Ziaja W (1991) Fizycznogeograficzne zróżnicowanie górskiej części północno-zachodniego Sörkapplandu (Spitsbergen). Część I: Uroczyska. *Zeszyty Naukowe Uniwersytetu Jagiellońskiego, Prace Geograficzne* 83:31–54
- Ziaja W (1992) Fizycznogeograficzne zróżnicowanie górskiej części północno-zachodniego Sörkapplandu (Spitsbergen). Część II: Tereny. *Zeszyty Naukowe Uniwersytetu Jagiellońskiego, Prace Geograficzne* 88:25–38



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