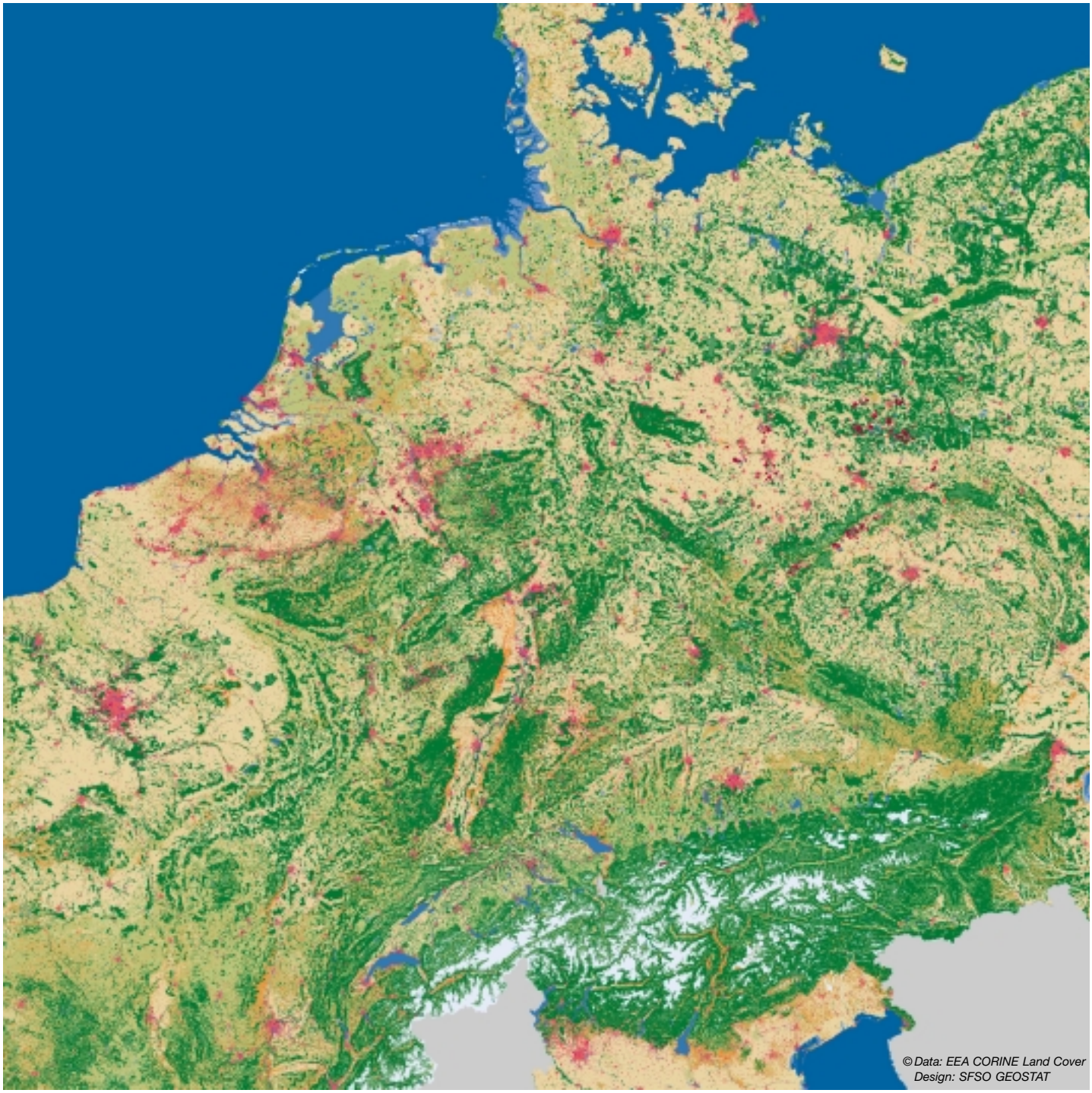
Swiss Land Use in the European Context

Integration of Swiss Land Use Statistics with CORINE Land Cover



OFS BFS UST

Office fédéral de la statistique
Bundesamt für Statistik
Ufficio federale di statistica
Swiss Federal Statistical Office

BUWAL Bundesamt für Umwelt, Wald und Landschaft
OFEFP Office fédéral de l'environnement, des forêts et du paysage
UFAFP Ufficio federale dell'ambiente, delle foreste e del paesaggio
SAEFL Swiss Agency for the Environment, Forests and Landscape

Neuchâtel, 1998

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Publisher

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Cover photo: The cover page presents CORINE Land Cover data for a part of central Europe with integrated compatible land use (statistics) data for Switzerland.
The colours and legend applied are identical with the map of Switzerland in the middle of this publication.

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Table of Contents

1 Introduction

Environmental questions, as a rule, are characterised by issues that bridge national boundaries. This aspect is especially important in densely settled Europe. Information resources concerning the condition of the environment present an indispensable knowledge base from which to approach problems such as environmental pollution or questions for a sustainable use of resources at a supranational level. Detailed data on land use and land cover are therefore a necessary component of any meaningful environmental information system and crucial for successful planning, related to environmental and nature conservation, agriculture and forestry as well as transportation and infrastructure.

The CORINE (**Co**-o**r**dination of **In**formation on the **E**nvironment) programme, which was initiated in the mid to late 1980s by the European Commission, strives to coordinate base information on the state of the European environment with the goal of creating and maintaining a community-wide environmental information system. CORINE Land Cover – as part of the larger programme – compiles an inventory of land cover data. In addition to the common development of methods and terminology within CORINE, these efforts have led to the building of an efficient European environmental information network. A welcome by-product is the considerably improved common understanding which has grown through the lengthy discussions. At the conference of the European Environment Ministers in June 1991 (in Dobriš Castle, Chechnya), a resolution to compile a report on the state of the environment in Europe was passed by all ministers present. This resolution also called for harmonized data sets, for which the already existing CORINE programme was adopted as the prototype and expanded to include the eastern European countries. The EFTA countries also supported this resolution. Since then a first report has appeared (Europe's Environment, The Dobris Assessment, 1995), and a follow-up report is to be published soon. Switzerland also began at this point to work with many parts of the CORINE programme (initially with atmospheric pollution, CORINAIR) and to integrate its federal data into the harmonized European database.

The Swiss Federal Statistical Office (SFSO), which is responsible for spatial information and statistics at the national level, periodically established land use statistics since 1912. At the beginning of the 1980s, the office completely revised its survey methodology in order to ensure systematic revisions and updating. In comparison to CORINE Land Cover, the Swiss Land Use Statistics is more semantically oriented towards land use, with 69 base categories. Although the 44 CORINE categories predominantly describe land cover, the similarities in both systems allow for a common examination on aggregate levels.

For this reason it makes sense to analyse in detail the results of the Swiss Land Use Statistics in terms of its compatibility to CORINE land cover. In the framework of a corresponding study it was proposed already a few years ago to aggregate and reassign the Swiss results in order to develop a new database suitable for European comparison. Such a data conversion – compatible with the terminology used in CORINE Land Cover – also addresses the repeated requests by organizations and persons involved in environmental assessment, monitoring, and politics, both in and outside of Switzerland. This effort is an important contribution to the improvement of common information for decision making in Europe, especially for environmentally oriented questions and problems, as well as for political matters

and measures concerning the latter. In addition, these data also provide the conditions for a visually consistent European cartographic presentation without a 'white spot' in the heart of our continent.

Land use statistics information from 1979–1985, which is presently being updated for the period 1992–1997, served as base for the generation of a relevant data set for comparison. The task of establishing a means of correspondence between the two classification systems consequently fostered a collaboration partnership between the Swiss Federal Statistical Office (SFSO) and the Swiss Agency for the Environment (SAEFL) on both a professional and technical level. SAEFL looks back on a longstanding collaboration with the European Environment Agency (EEA) as well as with its predecessor, the European Community Directorate General for the Environment. As a result of this relationship, SAEFL sought membership in the EEA in October of 1994 and made contributions to the new edition of the European Environmental Report, Dobris+3.

It is the expressed interest of both Swiss federal agencies to take an active part in future professional and content discussions regarding data sources and methodologies at the European level. Through the active exchange of digital data sets, co-operation with the EEA gains additional importance. Especially in border areas, these data represent considerable information and knowledge gain because different methodologies and results can be more easily compared and verified. SFSO has also established a longstanding relationship of fruitful collaboration with EUROSTAT, the Statistical Agency of the European Community.

The current results should supplement the Swiss Land Use Statistics by presenting a data set that achieves the greatest possible "Euro-compatibility". This can be clearly seen in the cartographic presentation in the middle of this publication. However, this publication can and should not replace conventional information of the Swiss Land Use Statistics. The authors are aware that this publication presents only an approximation, on an aggregated level, of the nomenclature of CORINE Land Cover; because of the differing investigation and interpretation methodologies it contains some ambiguities and imprecision. In the future, the methodology of the Swiss Land Use Statistics might be increasingly influenced by methods of digital remote sensing and image processing that will converge with the requirements of the CORINE nomenclature (BUNDESAMT FÜR STATISTIK 1996).

2 Synopsis of the data surveys

2.1 Swiss Land Use Statistics

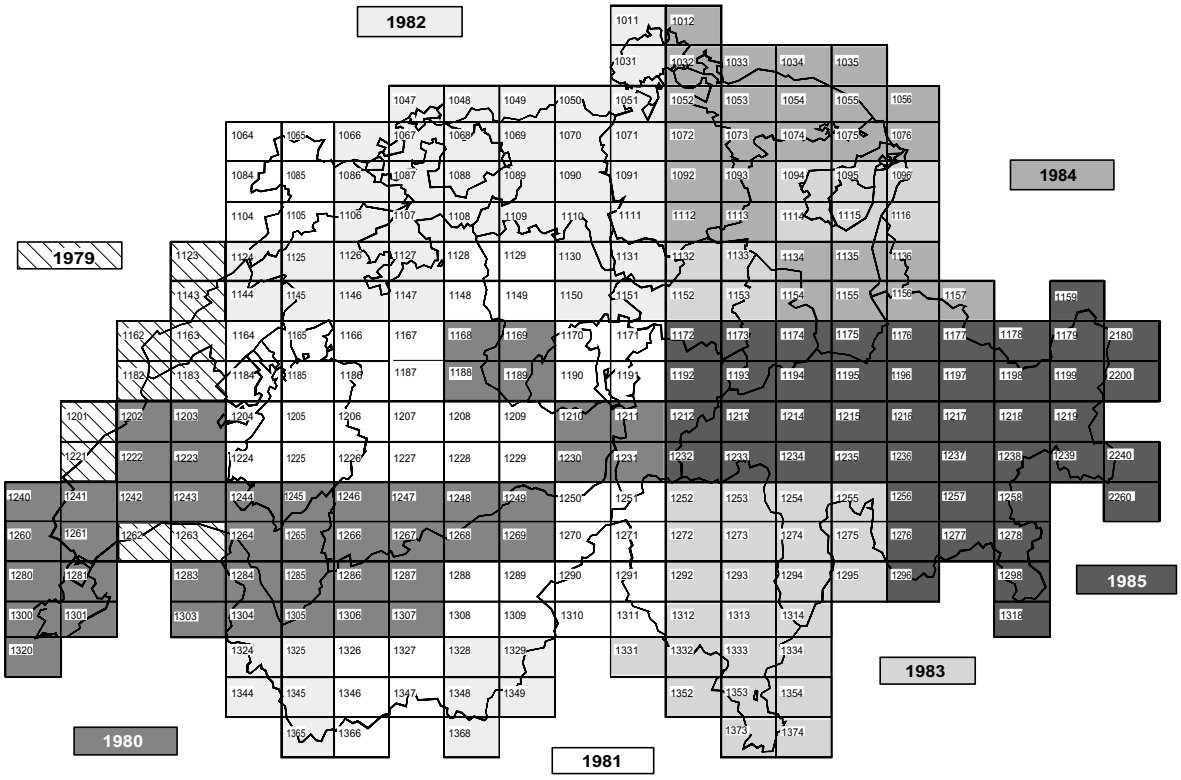
2.1.1 Project origins

In the years 1912, 1923/24, 1952 and 1972 land use statistics were published which, for various reasons, were inconsistent and, thus, could not easily be used for many purposes. They were especially unsuitable for comparison with each other, which made meaningful time series almost impossible. Therefore, the Swiss Federal Council decided on February 17, 1982, to initiate a new land use survey based on the interpretation of sample points on aerial photographs. This method had been developed at the end of the 1970's by the Institute of Photogrammetry at the Swiss Federal Institute of Technology in Lausanne and by the Institute for Local, Regional and National Planning at the Federal Institute of Technology in Zurich, together with the co-operation of several federal agencies.

2.1.2 Survey methods

Black and white aerial photography from the 1979–1985 aerial surveys of the Federal Office of Topography served as base data for the Swiss Land Use Statistics 1979/85 (Figure 2.1.2). Thus the 1979/85 data set represents land use in Switzerland at the beginning of the

Fig. 2.1.2 Year of flight surveys for the Swiss Land Use Statistics 1979/85



Subdivisions according to the Swiss national topographic map sheets, scale 1:25,000

1980's. The oldest data was gathered in 1979 (Western Switzerland), the most recent in 1985 (Canton of Graubunden). The data collection and interpretation work itself, which corresponds to the 1:25,000 scale series of topographical map sheets, began in early 1984 and was concluded at the end of 1992.

Around 4000 transparent sheets were prepared with a sample point grid of 100×100m resolution which were subsequently overlaid on the aerial photographs. The location of the sample points was governed by the intersection of the 100m co-ordinates of the topographic map of Switzerland. With the help of aerial photograph orientation elements (co-ordinates of the exposure position, angle of shot, focal length, image centre) and of the Swiss military's RIMINI digital elevation model, the correct positions of the individual sample points matching the geometry of the aerial photographs were calculated and these points automatically scribed. The result was a transparency with sample grids, frame marks, control points and labels for the kilometre grid which could be overlaid on the respective aerial photographs for interpretation.

Interpretation of land use was carried out using stereoscopes which allowe a three-dimensional examination of the photographs. During the process a total of 4.1 million sample points were assigned to one of the 69 categories in the land use catalogue. Decisive for the assignment of a specific land use code was the type of land use at the sample point. In order to standardize the interpretation and to avoid inconsistencies regarding the classification criteria, each point on each photo was checked by a second interpreter. Differing opinions were jointly discussed and resolved. Field inspections were used to make final decisions in situations of ambiguous land use and in areas difficult to interpret, as well as for verification of single points which remained questionable. The results of the interpretation process, the final land use codes on the sample point sheets, were then entered into a computer and transferred to the geographic information system (GIS) of GEOSTAT at SFSO (BUNDESAMT FÜR STATISTIK 1992b).

2.1.3 Nomenclature

The nomenclature for the Swiss Land Use Statistics was determined using two variables which were not always easy to keep separate – namely the type of land cover (vegetation, buildings, water etc.) and the specific function (agriculture, residential, industrial, recreation etc.). Thus, the present organization of the categories is not a consistent hierarchical system in the sense that the highest level represents land cover and the lower levels represent the subdivisions of function. Because of methodological and practical reasons rather, a mixed system was applied.

Table 2.1.3 shows an overview of the 69 base categories of the Swiss Land Use Statistics 1979/85. (BUNDESAMT FÜR STATISTIK 1992c). These categories were defined based on the opinions of a large number of experts within the administration as well as those of important data users, and subsequently tested in six regions. The experience gained during the course of the interpreation led to certain modifications. On the one hand, categories were abolished (e.g. cultivated farmland) which were not always ascertainable because the aerial photographs were taken at different times of the year. On the other hand, categories were added, where land use types were clearly identifiable but poorly defined in the existing catalogue.

Regarding international compatibility and environmental and ecological problems, the Swiss Land Use Statistics nomenclature contains a few flaws:

Table 2.1.3 Swiss Land Use Statistics 1979/85: 69 base categories

Forested areas

- **Forests (except brush forests)** (1)
  - **Closed forest** (1)
    - (11) Normal dense forest
    - (14) Forest stripes, edges
    - (10) Other forest
  - **Open forest** (2)
    - (12) Open forest (on unproductive areas)
    - (13) Open forest (on agricultural areas)
- **Brush forests** (2)
  - **Brush forest** (3)
    - (15) Brush forest
- **Woods** (3)
  - **Woods** (4)
    - (17) Groves, hedges
    - (18) Clusters of trees (on agricultural areas)
    - (19) Other woods

Agricultural areas

- **Orchards, vineyards, horticulture** (4)
  - **Vineyards** (5)
    - (71) Regular vineyards
    - (72) 'Pergola' vineyards
  - **Orchards** (6)
    - (75) Intensive orchards
    - (76) Rows of fruit trees
    - (77) Scattered fruit trees
  - **Horticulture** (7)
    - (78) Horticulture
- **Arable land, meadows and farm pastures** (5)
  - **Arable land and meadows** (8)
    - (81) Favourable arable land and meadows
    - (82) Other arable land and meadows
    - (73) Extensive vines
  - **Farm pastures** (9)
    - (83) Farm pastures
    - (84) Brush meadows and farm pastures
- **Alpine agricultural areas** (6)
  - **Mountain meadows** (10)
    - (85) Mountain meadows
  - **Alpine pastures** (11)
    - (88) Favourable alpine pastures
    - (89) Rocky alpine pastures
    - (86) Brush alpine pastures
    - (87) Remote and steep alpine meadows and pastures

Unproductive areas

- **Lakes** (7)
  - **Lakes** (12)
    - (91) Lakes
- **Rivers and river shores** (8)
  - **Rivers and river shores** (13)
    - (92) Rivers
    - (69) River shores
- **Unproductive vegetation** (9)
  - **Unproductive vegetation** (14)
    - (16) Scrub vegetation
    - (95) Wetlands
    - (96) Water shore vegetation
    - (97) Unproductive grass and shrubs
- **Bare land** (10)
  - **Bare land** (15)
    - (99) Bare land

Settlement and urban areas

- **Built-up areas** (11)
  - **Buildings** (16)
    - (25) One- and two-family houses
    - (26) Terraced houses
    - (27) Blocks of flats
    - (28) Agricultural buildings
    - (29) Unspecified buildings
  - **Surroundings of buildings** (17)
    - (45) Surroundings of one- and two-family houses
    - (46) Surroundings of terraced houses
    - (47) Surroundings of blocks of flats
    - (48) Surroundings of agricultural buildings
    - (49) Surroundings of unspecified buildings
- **Industrial areas** (12)
  - **Industrial buildings** (18)
    - (21) Industial buildings
  - **Industrial grounds** (19)
    - (41) Industrial grounds
- **Special urban areas** (13)
  - **Special urban areas** (20)
    - (24) Buildings in special urban areas
    - (62) Energy supply plants
    - (63) Waste water treatment plants
    - (61) Other supply or waste treatment plants
    - (65) Quarries, mines, dumps
    - (66) Construction sites
    - (20) Ruins
- **Recreational areas and cemeteries** (14)
  - **Recreational areas and cemeteries** (21)
    - (23) Buildings in recreational areas
    - (51) Sport grounds
    - (52) Garden allotments
    - (53) Camping, caravan sites
    - (54) Golf courses
    - (56) Cemeteries
    - (59) Public parks
- **Transportation areas** (15)
  - **Roads areas** (22)
    - (31) Motorways
    - (32) Green motorway environs
    - (33) Roads and paths
    - (34) Parking areas
    - (68) Green road environs
  - **Railway areas** (23)
    - (35) Railway station grounds
    - (36) Railway lines
    - (67) Green railway environs
  - **Airports and airfields** (24)
    - (37) Airports
    - (38) Airfields, green airport environs

Legend

- 1 - 15 = Aggregation BN8515
- 1 - 24 = Aggregation BN8524
- (10) - (99) = Basic categories

– Under the theme of agriculture a separate delineation for land that is intensively cultivated is missing because it is difficult to determine from the black and white aerial photographs.

– Densely forested areas were principally differentiated using structural characteristics (coverage, canopy density) and not ecological (composition of tree species, ratio of mixture) or forestry criteria (calculation of timber volume, stability of forest stand).

– There is no differentiation for surface coverage (sealed or not sealed) within the settlement and urban areas.

2.2 The CORINE Land Cover Project

2.2.1 Project origins

The CORINE Land Cover Project is a component of the CORINE programme and carries the task of building a consistent environmental information system within the European Community. The programme was introduced, with the support of the European Commission, in 12 Community members states in the years 1985 to 1990. Since 1991, as a feature of the PHARE programme, it has been extended to central and middle European neighbour states. Other components of the CORINE programme also deserve mention:

– CORINE Biotope Sites – a classification and description of the habitat systems throughout Europe using a uniform nomenclature.

– CORINAIR – a comprehensive quantification of emissions in the atmosphere per unit area.

– CORINE Soil Erosion – a project to identify the risk of soil erosion and degradation of important land resources in the southern region of the European Community.

All of these projects have in common a direct or indirect connection to land cover issues.

In addition to the environmental information system as a “final product”, the co-ordination effort for data collection and common development of methodologies in members states is stressed. As a result, the classification schemes and nomenclature serve as a reference system within the European Community and to a large extent for the eastern European neighbour states as well.

The recognition that, in previous decades, the affect of human exploitation has caused manifold consequences such as changes in land cover proved to be fundamental for the implementation of the CORINE Land Cover data collection. Important examples include:

– The proliferation of steppes and deserts in regions of southern Europe.

– The rapid disappearance of large areas of forests.

– The abandonment of unproductive agricultural areas and the ensuing successions of vegetative growth (proliferation of shrubs and forests).

– Large scale drying-up of wetlands.

– Permanent growth of urban and suburban structures (inland as well as in coastal areas).

In contrast to the CORINE Biotope Project, which could rely on wide reaching consistent national investigations, pilot studies for CORINE Land Cover showed that existing national information were heterogeneous, inconsistent and incomplete. Because land cover data as well as data on terrain, hydrological conditions, etc. represent key variables for the assessment of the state of the environment, a decision was made to develop a concise methodology suitable for duplication by all member states (EUROPEAN COMMISSION DIRECTORATE-GENERAL ENVIRONMENT, NUCLEAR SAFETY AND CIVIL PROTECTION 1993).

An objective, comprehensible investigation methodology would provide for the creation of a consistent dataset and allow, in addition to information about the actual land cover, for a monitoring or periodic updating possibility in order to identify both mid and long-term changes. Apart from the goal of completing a full survey coverage in the participating countries, the classification definitions needed to be unambiguous and definite, minimizing the possible range of subjective interpretation. The nomenclature should further provide a high degree of robustness to allow for follow-up investigations. It is not surprising that these intentions were identical to the goals of the Swiss Land Use Statistics.

2.2.2 Survey methodology

The spatial resolution criteria (survey scale) and procedures for the identification and delineation of the spatial units were especially significant for the survey methodology:

a) Survey scale and minimum mapping units

A scale of 1:100,000 was adopted as the mapping scale because smaller scales, due to the desired level of detail and resolution, were considered inadequate. Consequently, the smallest identifiable mapping unit was defined as 25 hectares. This yields, in relation to scale,

- clear criteria of homogeneity,
- a significant size of land areas identified per land cover class,
- units clearly distinguishable from surrounding units and
- an expressive and clear definition for further use.

The mapping scale and the spatial resolution used is especially suitable for the task of master planning and spatial overviews at a national level. Additional benefits include a high degree of compatibility of working scales within the entire CORINE project, favourable cost-benefit ratios and good availability of topographical background data at this level. Problematic, however, is the use of various map projection systems by different member states (ARONOFF 1989).

b) Image processing and interpretation

The methodology for image processing and interpretation was first tested in a pilot project in order to establish a definite catalogue of criteria. The focus of this implementation was a computer-supported visual photo interpretation of satellite data (Landsat MSS, TM, SPOT HRV). At the same time, topographical data (e.g. drainage network) and aerial photographs were consulted to support the visual interpretations. Because Landsat MSS data (spatial resolution of the original pixels 57×79m) proved too coarse during the pilot project, quality control using Landsat TM or SPOT HRV (original resolution 30×30m and 20×20m respec-

tively) was recommended. Although the methodology and the demanded spatial resolution allowed using the cheaper Landsat MSS data for the full coverage survey, considerable time savings were achieved using the higher resolution data.

The satellite data was geo-referenced and orthogonally corrected with the aid of geographical background data and, when necessary, with digital elevation models. The successive false colour digital image processing aimed at achieving optimal visible contrasts between the various vegetation units and the remaining forms of land cover and land use. After this, the data was exposed onto photographic film and enlarged to a scale of 1:100,000.

The interpretation of land cover and the delineation of homogenous elements was carried out by tracing onto transparencies (which contained the drainage network layer of the topographical map series 1:100,000). The smallest mapping unit considered was 25 ha, and a minimum width of 100 m had to be maintained for long elements (such as river beds, etc.). After delineation and codification according to the CORINE Land Cover nomenclature, the transparencies were either digitized by hand or scanned, vectorized and attributed. Verification using sample point investigations or direct comparison of the results with high-resolution aerial photography was finally carried out. Available background data (land use maps, certain topographical map series) was consulted in this phase as long as it proved suitable for validation. This synopsis should not lead to the false assumption of a purely sequential process. Especially the last few steps were applied iteratively, i.e. repeated several times, in order to achieve correct results.

The work procedures can be outlined as follows:

1. Preliminary work: selection of satellite data (Landsat MSS, Landsat TM, SPOT HRV) for image processing. Acquisition of background data (e.g. drainage system), ancillary data (e.g. maps and aerial photographs) and meta-information. Production of the interpretation transparencies with imprinted drainage network at the scale of 1:100,000.

↓

2. Geometrical correction of photographic data (geo-referencing). Generation of false-colour infrared images at the scale of 1:100,000 using digital image processing techniques.

↓

3. Computer based photo interpretation, identification and delineation of land cover units on interpretation transparencies.

↓

4. Digitizing of the mapped units from transparencies or scanning and vectorizing.

↓

5. Verification using statistical sample methods or comparison with large-scale aerial photography.

2.2.3 Nomenclature

Mapping scale and spatial resolution, as well as available data sources make up the essential criteria for the degree of hierarchy in the CORINE Land Cover legend. Additionally, the large geographical extent to be covered by this nomenclature must be considered. The basic classification principle forms a binary structure which avoids ambiguousness at the interpretation level.

The CORINE Land Cover legend and its basic definitions (Table 2.2.3) present the consensus agreement of different EU member states, and are the result of many expert discussions. The legend is organized into three hierarchical levels of spatial resolution and accompanying attribute information which correspond with the following presentation scales:

– Level 1 (5 land cover classes): Major categories of land cover on the planet, especially useful for international comparisons.

– Level 2 (15 land cover classes): for use at scales between 1:500,000 and 1:1,000,000 (e.g. for European overview maps).

– Level 3 (44 land cover classes): for use at scales around 1:100,000 (for national overview maps).

The CORINE concept allows for further differentiation at national levels (Levels 4 and 5) and does not impose any restrictions to the collaborating countries as to how such a differentiation is defined and achieved. It is, however, compulsory that these levels represent subdivisions of the corresponding Level 3 category and are clearly related to only one unit in the upper hierarchy.

The CORINE Land Cover Project can be briefly outlined as follows:

- Area covered: 2,3 million km², 12 nations.
- Spatial extent: 62° N to 28° S, 14° W to 29° E.
- Working scale: 1:100,000, with 1500 standard map sheets using 10 different projection systems.
- Smallest mapping unit area 25ha using more than 700,000 base units (polygons). Disk space used by vector data ~ 1 gigabyte.
- Land use differentiation in three levels of 5, 15 and 44 classes.

Table 2.2.3 CORINE Land Cover nomenclature in three levels of hierarchy

Level 1	Level 2	Level 3
1. Artificial surfaces	1.1 Urban fabric	1.1.1 Continuous urban fabric 1.1.2 Discontinous urban fabric
	1.2 Industrial, commercial and transport units	1.2.1 Industrial or commercial units 1.2.2 Road and rail networks and associated land 1.2.3 Port areas 1.2.4 Airports
	1.3 Mine, dump and construction sites	1.3.1 Mineral extraction sites 1.3.2 Dump sites 1.3.3 Construction sites
	1.4 Artificial non-agricultural vegetated areas	1.4.1 Green urban areas 1.4.2 Sport and leisure facilities
2. Agricultural areas	2.1 Arable land	2.1.1 Non-irrigated arable land 2.1.2 Permanently irrigated land 2.1.3 Rice fields
	2.2 Permanent crops	2.2.1 Vineyards 2.2.2 Fruit trees and berry plantations 2.2.3 Olive groves
	2.3 Pastures	2.3.1 Pastures

Table 2.2.3 Continuation

Level 1	Level 2	Level 3
	2.4 Heterogeneous agricultural areas	2.4.1 Annual crops associated with permanent crops 2.4.2 Complex cultivation patterns 2.4.3 Land principally occupied by agriculture, with significant areas of natural vegetation 2.4.4 Agro-forestry areas
3. Forest and semi-natural areas	3.1 Forests	3.1.1 Broad-leaved forest 3.1.2 Coniferous forest 3.1.3 Mixed forests
	3.2 Shrub and/or herbaceous vegetation associations	3.2.1 Natural grassland 3.2.2 Moors and heathland 3.2.3 Sclerophyllous vegetation 3.2.4 Transitional woodland scrub
	3.3 Open spaces with little or no vegetation	3.3.1 Beaches, dunes and sand plains 3.3.2 Bare rock 3.3.3 Sparsely vegetated areas 3.3.4 Burnt areas 3.3.5 Glaciers and perpetual snow
4. Wetlands	4.1 Inland wetlands	4.1.1 Inlands marshes 4.1.2 Peatbogs
	4.2 Coastal wetlands	4.2.1 Salt marshes 4.2.2 Salines 4.2.3 Intertidal flats
5. Water bodies	5.1 Inland waters	5.1.1 Water courses 5.1.2 Water bodies
	5.2 Marine waters	5.2.1 Coastal lagoons 5.2.2 Estuaries 5.2.3 Sea and ocean

3 Transfer of nomenclature

3.1 Problem analysis

A fundamental difference between the investigation methodology of the two classification systems lies in the delineation of land use and land cover types. While the Swiss Land Use Statistics identifies land utilization at each sample point, CORINE Land Cover divides the surface area into more or less homogenous units of 25 ha or larger which are then assigned the corresponding type of land cover. This has implications for the respective nomenclature. Small areas of land use (groves, clusters of trees, ruins, buildings) are only ascertained at sample points or as small spots in the surrounding area. In contrast, mixed types such as heterogeneously structured agricultural areas or complex plot structures require larger areas in order to be properly defined.

The differing methods of delineation result in differences in the nomenclature and thereby make it difficult, if not impossible, to translate the Swiss Land Use Statistics into corresponding classes at Level 3 of CORINE Land Cover. For this reason, a preference was made to relate the base categories of the Swiss Land Use Statistics with Level 2 of CORINE Land Cover.

Apart from the content and thematic problems of translating one nomenclature into another, differences in the criteria for delineation of semantically identical land use types exist which, however, could hardly be considered. For example, the definition of forest in CORINE Land Cover requires an approximate canopy coverage of 75%, while certain forest types are identified already with 20% coverage in the Swiss Land Use Statistics. Forest is further differentiated in the Swiss Land Use Statistics as dense forest (from 60% canopy cover) and open forest (20%–60%), so that only the former can be assigned to CORINE Land Cover Type 3.1 Forests, while the latter corresponds to Land Cover type 2.4 Heterogeneous agricultural areas or 3.2 Shrub and/or herbaceous vegetation associations (Chapter 3.3.1).

The main difficulties encountered in relating the Swiss Land Use Statistics base categories to Level 2 of CORINE were as follows:

- Impossible assignment because the corresponding utilization is not identified in the Swiss Land Use Statistics (e.g. 2.1 Arable land, 2.4 Heterogeneous agricultural areas).
- Problematic assignment due to uncertainties in the definition of the category in CORINE Land Cover (e.g. shrub forests, alpine pastures).
- Difficult assignment because a Swiss Land Use Statistics base category needed to be divided between two categories of CORINE Land Cover (e.g. 13 Open forest on agricultural areas, 18 Clusters of trees on agricultural areas).
- Impossible assignment because certain Swiss Land Use Statistics base categories could be included into several CORINE Land Cover categories (e.g. 19 Other woods, 20 Ruins).

3.2 Synthetic model for the assignment of 'Arable land'

Because of poor recognition in black and white aerial photographs, arable land is not ascertained in the Swiss Land Use Statistics but included in the more extensive category of Arable land and meadows. In order to achieve better compatibility, a solution had to be found to better define arable land before a straightforward reassignment of the Land Use Statistics categories to the CORINE Land Cover nomenclature could be made. It should be evident that a costly delineation by conventional interpretation of aerial photographs was not feasible. Thus a pragmatic approach was chosen to derive and generate a new category for arable land by partially reassigning the existing category for arable land and meadows supported by a model using additional spatial data sets. The result of such a reassignment should, in any case, be subject to closer examination and verification with aerial photographs. For this reason it must only be considered provisional.

Any survey of arable land must distinguish between two principal definitions: Open, tilled land at the time of the investigation on the one hand, and potential arable land (suitable for arable farming) on the other. Because the situation and extension of open arable land changes seasonally, it is therefore difficult to keep the updating of digital spatial data cost effective which may explain the lack of such data. However, it is helpful that three GIS data sets are available at a national level with qualitatively different information for defining arable land:

- Information on crop rotating areas delineated and protected by regional planning authorities for crisis management, which contain highly suitable arable land. This information is not available in digital format at full coverage but for a few selected cantons only.
- Agricultural zone boundaries divide the area of permanent settlements of Switzerland into eight zones, including a zone for arable land. The digitization of these zones was only completed at the beginning of 1998 and the digital data therefore was not available at the time the present project was carried out.
- The Soil Suitability Map of Switzerland at a scale of 1:200,000 was, at the time of the classification, the only GIS data set with spatial information on land arability available for all of Switzerland.

3.2.1 The digital Soil Suitability Map of Switzerland

The Soil Suitability Map of Switzerland, at a scale of 1:200,000 shows soil-land units defined on the basis of geomorphological and pedological criteria which were assessed and aggregated in regards to their agricultural and forestry utilization potential. This was done through the appraisal of the pedological characteristics of the map units, dependent on the major soil groups. The map is strongly generalized and thus reflects regional and local conditions only insufficiently (BUNDESAMT FÜR RAUMPLANUNG, 1980).

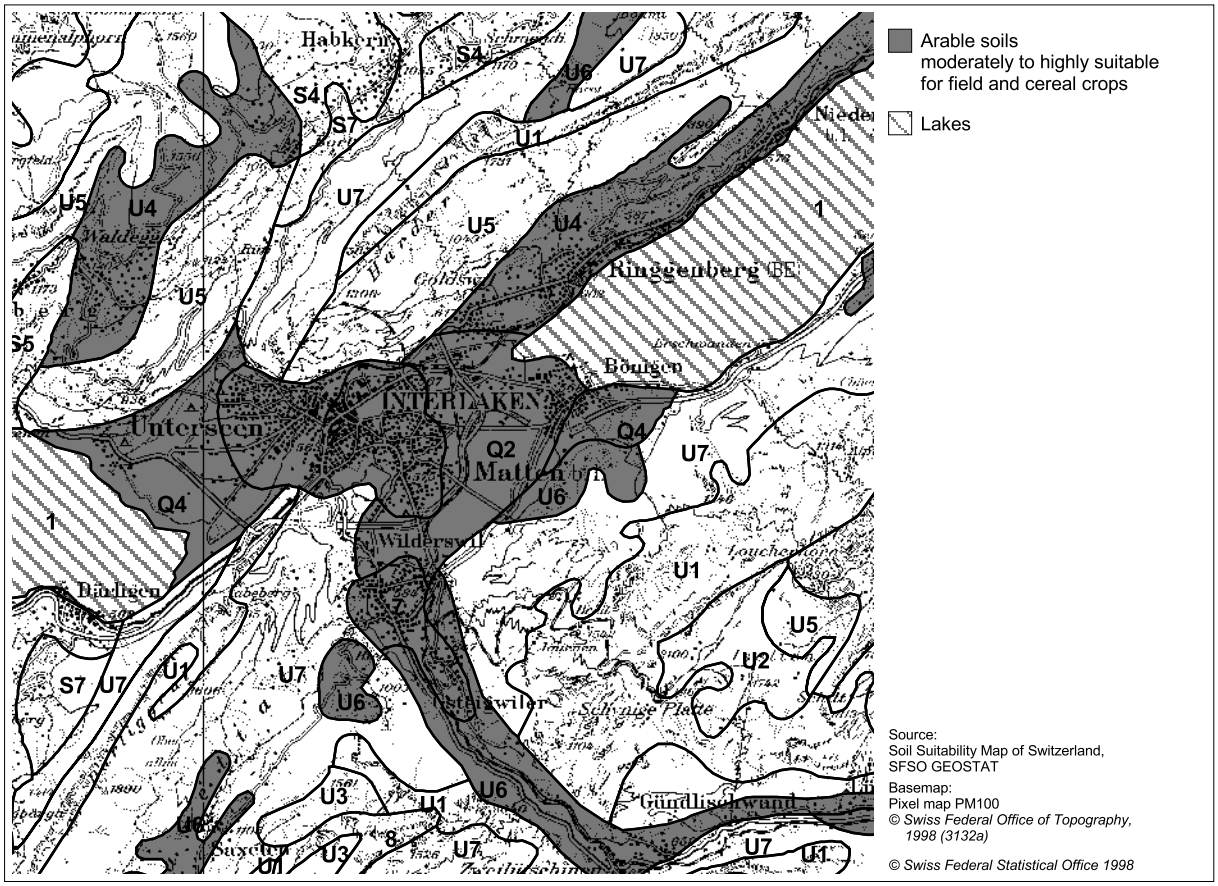
The compilation of the mapping units was carried out using geological map series at scales 1:25,000 and 1:200,000, geo-technical map series at 1:200,000, geomorphological and topographical maps at 1:25,000 and 1:50,000 as well as aerial photography from the Federal Office of Topography. In addition, soil maps from the Swiss Federal Research Station for Agroecology and Agriculture were used. After a delineation of physiographic units at scales 1:25,000 and 1:50,000, sample surveys were carried out in the field. The number of samples totalled 200 representative points for the mapping units and five further sample points per

map sheet at a scale of 1:25,000. After the evaluation (identification in the field and laboratory analyses) and definitive delineation, the assignment of soil properties (suitabilities) was made.

Regarding its qualitative evidence (attached attributes), the map is still current. However, due to the age of the soil surveys some of the soil units need to be spatially redefined and reassessed. Since the existence of this map series, for example in the area of organic soils (histosols), a significant amount of the surface area has been changed through melioration from pasture into arable land and may therefore need to be classified differently. It is therefore not surprising that assignments based on these (obsolete) soil units result in the same degree of inaccuracy as their base data. This is the case, for example, with the delineation of the arable land category, based on the recommendations of the Soil Suitability Map (Figure 3.2.1): the actual area covered should clearly exceed the recommended area because, due to the melioration measurements described above, a large portion of the organic soil has been drained and ploughed under.

Fig 3.2.1 Soils well suitable for agricultural cultivation as identified by the Soil Suitability Map

Area of Interlaken 1:100,000



Map, above right: detail of the base data set of CORINE Land Cover

1.1 Urban fabric
1.2 Industrial, commercial and transport units
1.3 Mine, dump and construction sites
1.4 Artificial non-agricultural vegetated areas
2.1 Arable land
2.2 Permanent crops
2.3 Pastures
2.4 Heterogeneous agricultural areas
3.1 Forests
3.2 Shrub and/or herbaceous vegetation associations
3.3 Open spaces with little or no vegetation
4.1 Inland wetlands
5.1 Inland waters
NC Not classified

This data set is used to determine surface area statistics. At the same time it forms a base for spatial generalization as well as for the polygon and grid data sets which are spatially and thematically compatible with CORINE Land Cover.

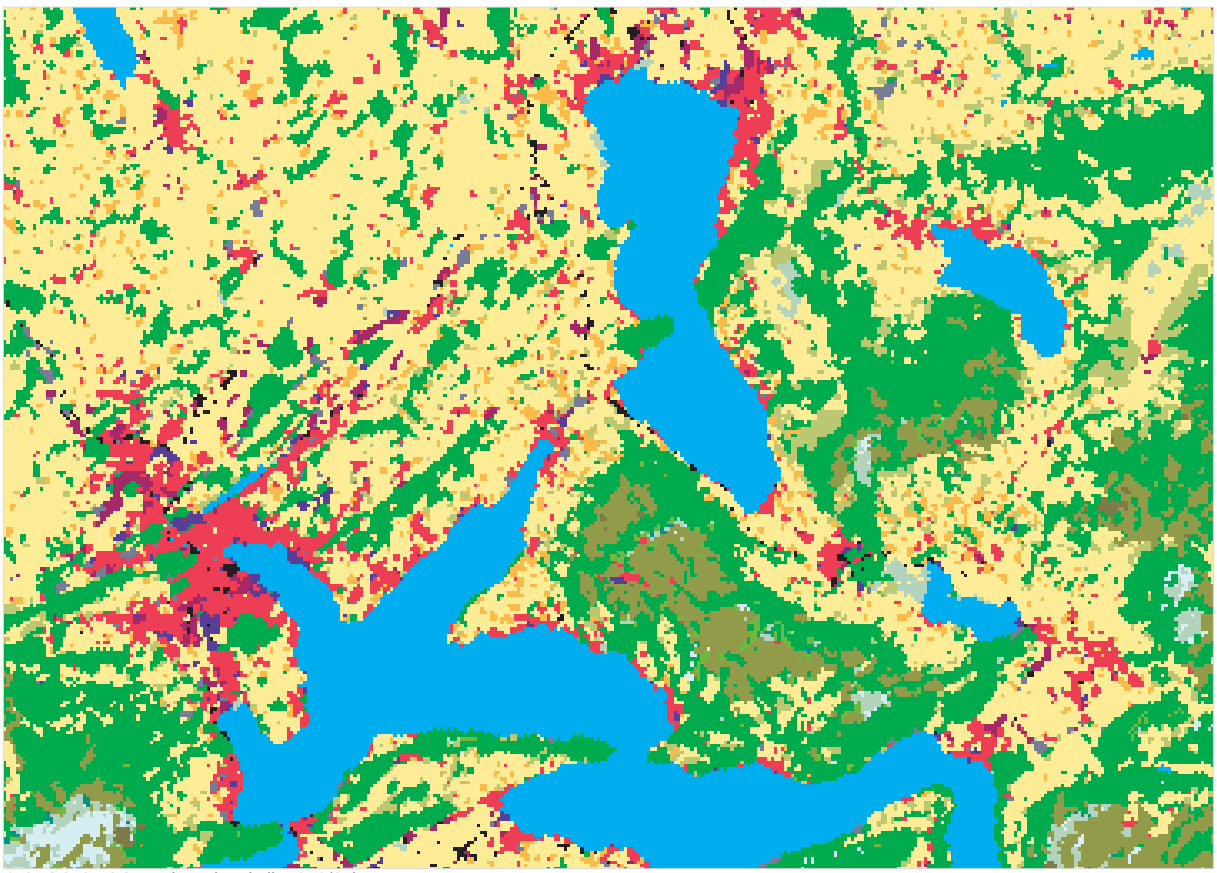
Map, below right: detail of the Land Use Map of Switzerland

1 Closed forest
2 Open forest
3 Brush forest
4 Arable land, meadows
5 Farm pastures
6 Vineyards
7 Orchards, horticulture
8 Mountain meadows
9 Alpine pastures
10 Building areas
11 Industrial areas
12 Recreational areas
13 Special urban areas
14 Traffic facilities
15 Lakes and rivers
16 Unproductive vegetation
17 Bare land

The Land Use Map of Switzerland is the result of an iterative process for which the Swiss Land Use Statistics served as a base. The first step was to aggregate the 69 Swiss Land Use Statistics categories into the 17 new categories shown on the map. Despite of the generalization effect, there were still isolated grid cells disturbing the map presentation. In further generalization steps these codes were reassigned using image processing filters and smoothing algorithms which took the specific neighbourhood of these units into consideration to obtain a consistent and homogenous area usage.

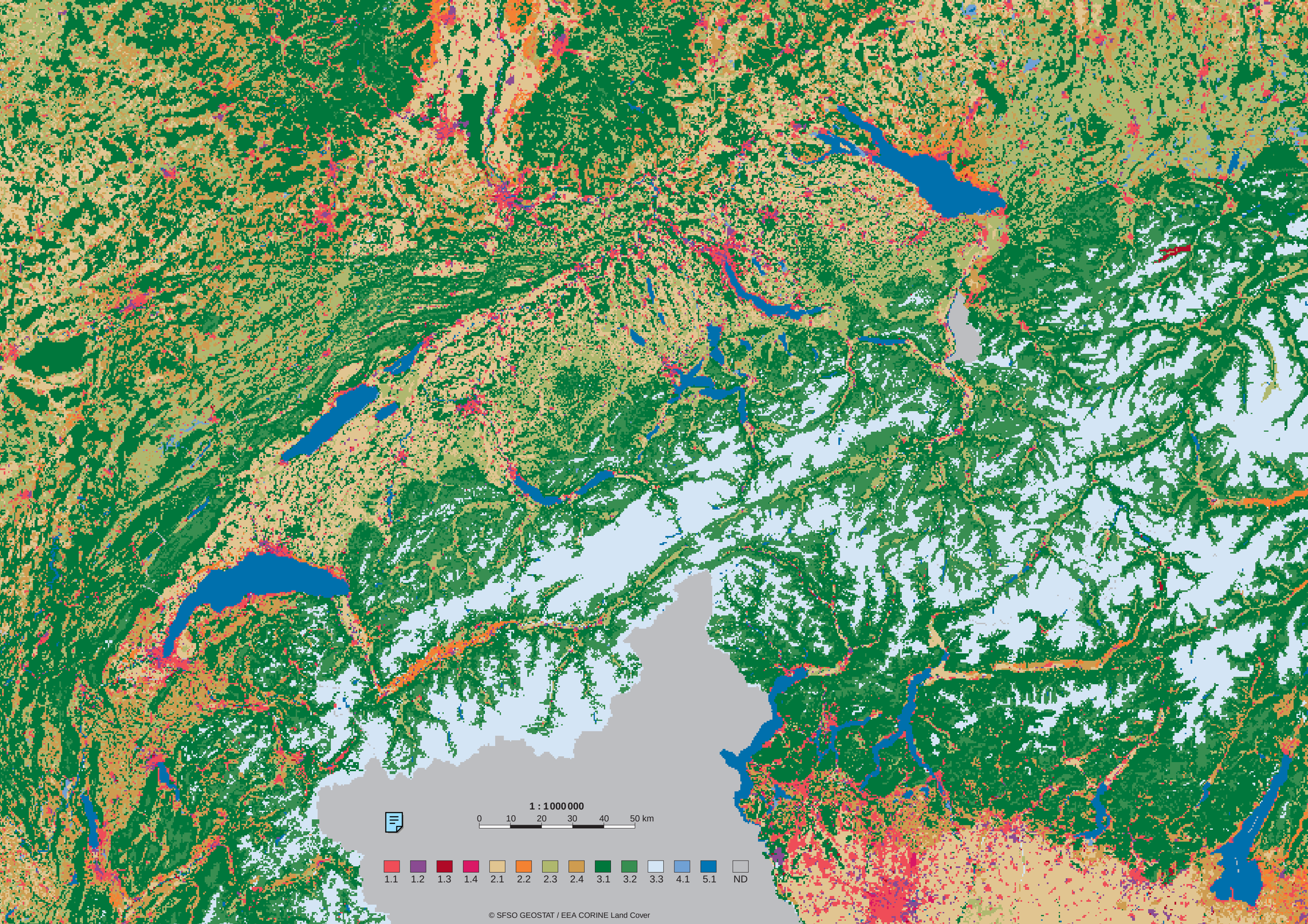
1 : 200 000

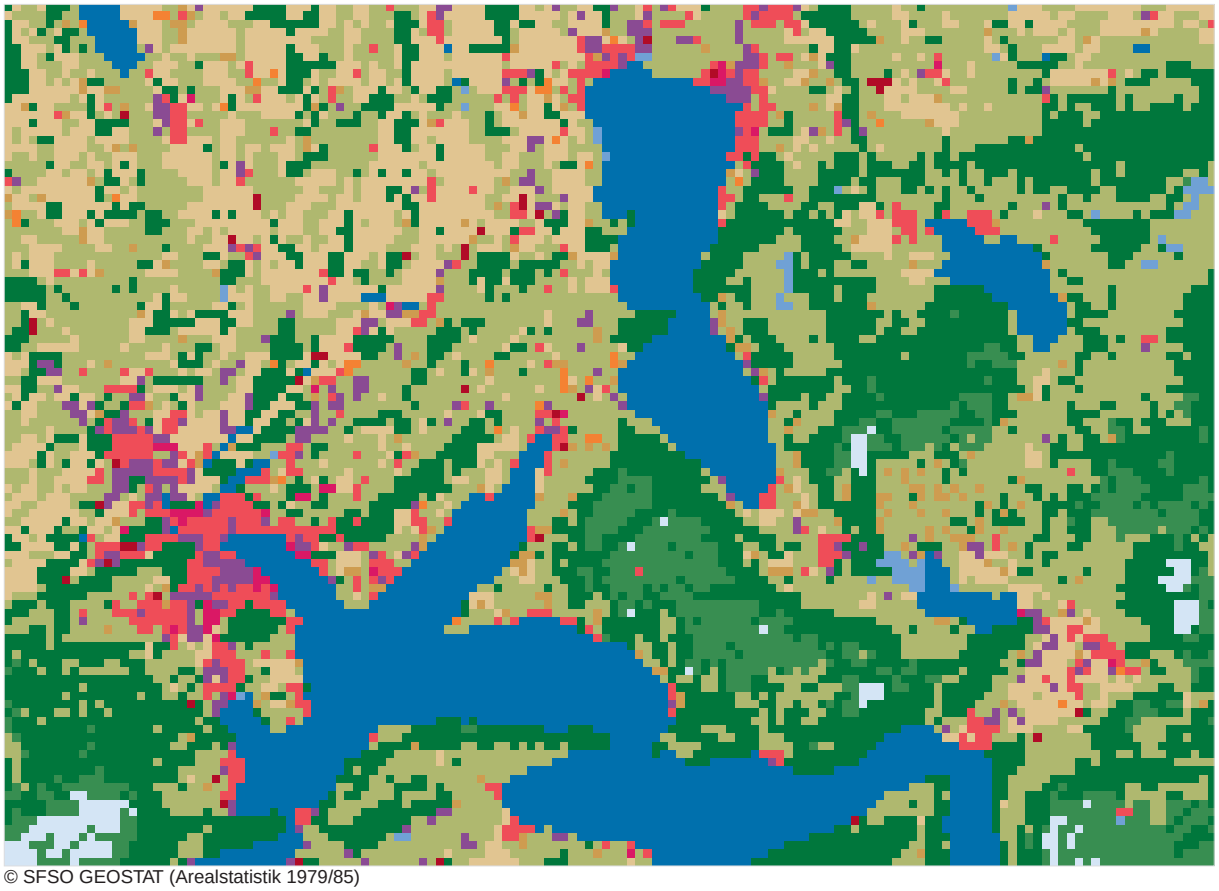
0 1 2 3 4 5 km



1 : 200 000

0 1 2 3 4 5 km

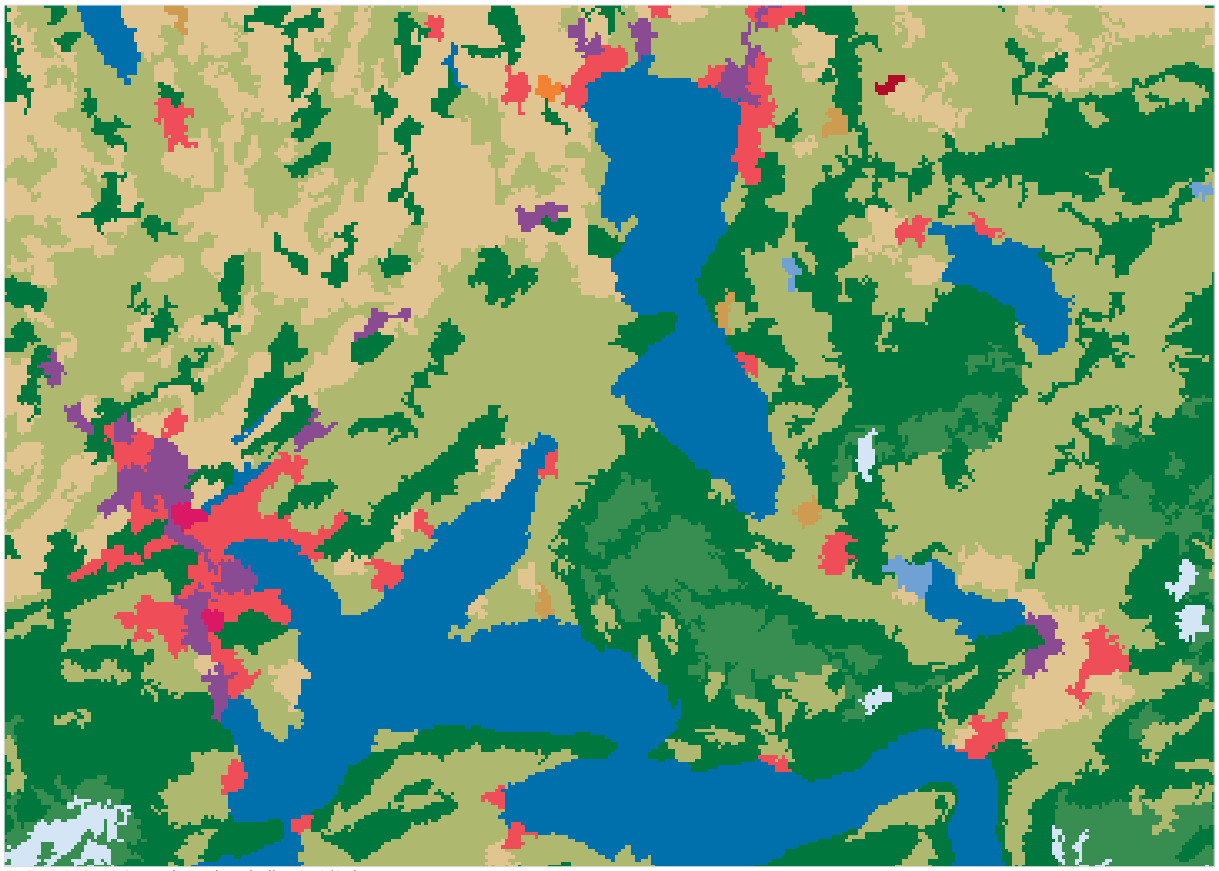

1 : 1 000 000
0 10 20 30 40 50 km
1.1 1.2 1.3 1.4 2.1 2.2 2.3 2.4 3.1 3.2 3.3 4.1 5.1 ND
© SFSO GEOSTAT / EEA CORINE Land Cover



1.1 1.2 1.3 1.4 2.1 2.2 2.3 2.4 3.1 3.2 3.3 4.1 5.1

1 : 200 000

0 1 2 3 4 5 km



1.1 1.2 1.3 1.4 2.1 2.2 2.3 2.4 3.1 3.2 3.3 4.1 5.1

1 : 200 000

0 1 2 3 4 5 km

Map on the centrefold: depiction of Switzerland and neighbouring countries (grid data set)

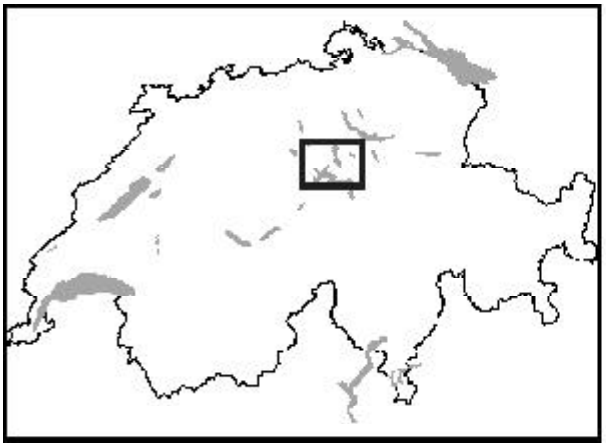
Map, above left: detail of the grid data set

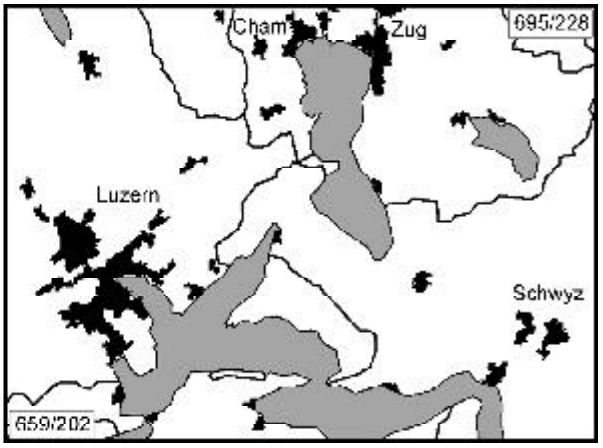
Map, below left: detail of the polygon data set

1.1 Urban fabric
1.2 Industrial, commercial and transport units
1.3 Mine, dump and construction sites
1.4 Artificial non-agricultural vegetated areas
2.1 Arable land
2.2 Permanent crops
2.3 Pastures
2.4 Heterogeneous agricultural areas
3.1 Forests
3.2 Shrub and/or herbaceous vegetation associations
3.3 Open spaces with little or no vegetation
4.1 Inland wetlands
5.1 Inland waters
ND No data available

The two map details show the CORINE Land Cover compatible grid and polygon data sets derived from the Swiss Land Use Statistics.
The legend above is also applicable to the map on the title page.

Information on the location of the colour map details:





3.2.2 The re-assignment for meadow and pasture in arable land

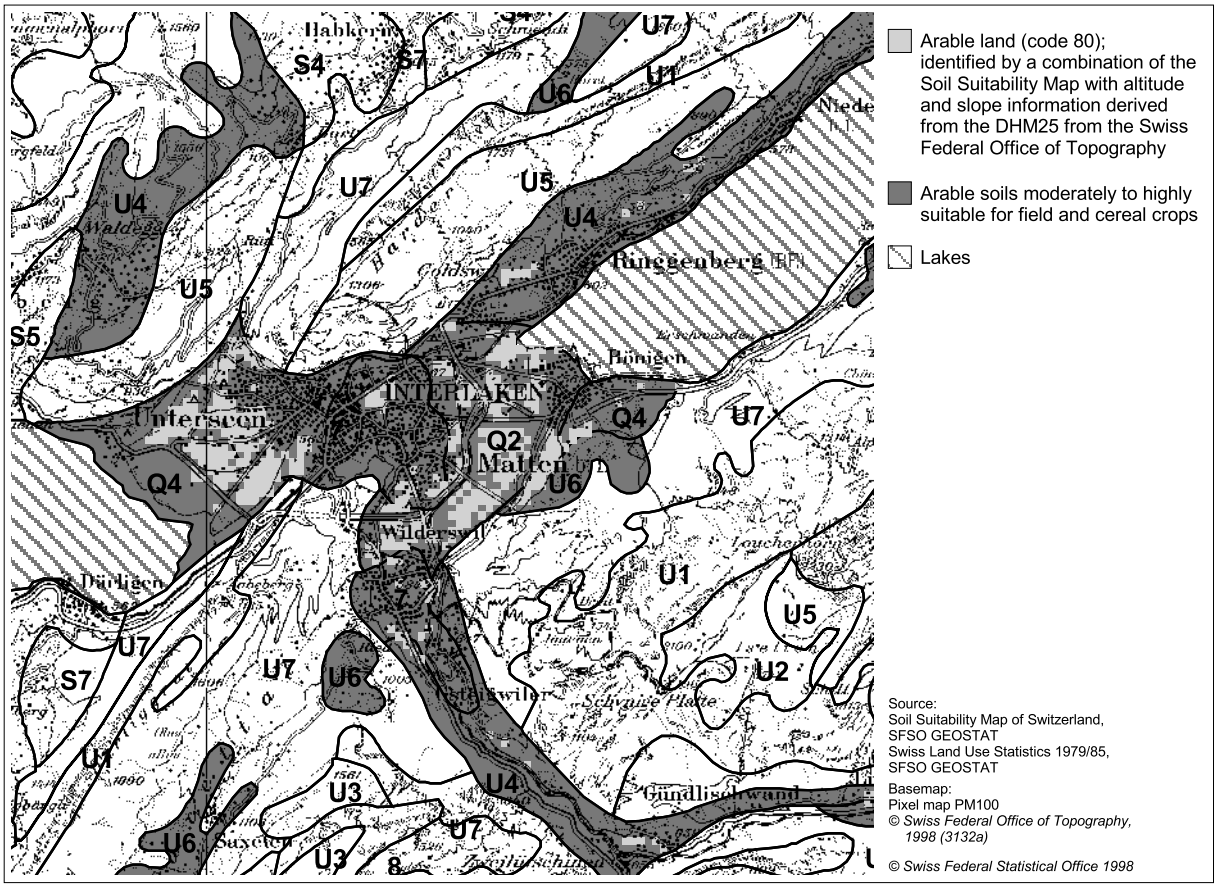
In order to develop the category of arable land through the combination of the Swiss Land Use Statistics results and the Soil Suitability Map, several procedures were attempted including the digital height model (DHM25) from the Federal Office of Topography. During the modelling process, different threshold values for the definition and delineation of the base categories (81, 82, 83) of Swiss Land Use Statistics, for altitude and slope as well as for soil suitability were applied.

Finally, a sample point had to fulfill the following criteria in order to be assigned a new land use category Arable land:

- affiliation to the Swiss Land Use Statistics base category Favourable arable land and meadows (81)
- location within a mapping unit of the Soil Suitability Map with moderate to very high suitability for field or cereal crops, or location in an area bordering category 7 (settled area)
- altitude of up to 900 m above sea level
- maximum slope of 20%

The determination of the resulting area of the new category Arable land yielded a total of 418,732 ha. When compared to the planimetrically determined area for crop rotation (453,246 ha) this value seems indeed plausible, especially considering that an additional expansion of this large-area land use could be expected due to the spatial generalization. The new Arable land category was assigned a provisional code 80 (Figure 3.2.2).

Fig. 3.2.2 Provisional land use statistics category Arable land (Code 80) **Area of Interlaken 1:100,000**



3.3 Assignment of Swiss Land Use Statistics codes

After the category for Arable land was established, all of the now 70 categories were assigned a land cover type listed in CORINE Land Cover Level 2 (Table 3.3). This matching was limited to 13 of the original 15 classification types since the two land cover types 4.2 Coastal wetlands and 5.2 Marine waters do not exist naturally in landlocked Switzerland.

During the assignment of the Swiss Land Use Statistics base categories to the 13 CORINE Land Cover classification types, the following difficulties and uncertainties were resolved.

Table 3.3 Assignment of the categories of Swiss Land Use Statistics to Level 2 of CORINE Land Cover

Level 1 CORINE	Level 2 CORINE	Swiss Land Use Statistics base categories
1. Artificial surfaces	1.1 Urban fabric	25 One and two family houses
		26 Terraced houses
		27 Blocks of flats
		28 Agricultural buildings
		29 Unspecified buildings
		45 Surroundings of one and two family houses
		46 Surroundings of terraced houses
		47 Surroundings of blocks of flats
		48 Surroundings of agricultural buildings
		49 Surroundings of unspecified buildings
	1.2 Industrial, commercial and transport units	21 Industrial buildings
		41 Industrial grounds
		61 Other supply or waste treatment plants
		62 Energy supply plants
		63 Waste water treatment plants
		24 Buildings in special urban areas
		31 Motorways
		32 Green motorway environs
		33 Roads and paths
		34 Parking areas
		68 Green road environs
		35 Railway station grounds
		36 Railway lines
		67 Green railway environs
		37 Airports
		38 Airfields, green airport environs
	1.3 Mine, dump and construction sites	65 Quarries, mines, dumps
		66 Construction sites
	1.4 Artificial non-agricultural vegetated areas	51 Sport grounds
		52 Garden allotments
		53 Camping, caravan sites
		54 Golf courses
		56 Cemeteries
		59 Public parks
		23 Buildings in recreational areas

Table 3.3 Continuation

Ebene 1 CORINE	Ebene 2 CORINE	Grundkategorien Arealstatistik
2. Agricultural areas	2.1 Arable land	81 Favourable arable land and meadows (partially)
	2.2 Permanent crops	71 Regular vineyards 72 'Pergola' vineyards 75 Intensive orchards 76 Rows of fruit trees 78 Horticulture
	2.3 Pastures	73 Extensive vines 81 Favourable arable land and meadows (partially) 82 Other arable land and meadows 83 Farm pastures 84 Brush meadows and farm pastures
	2.4 Heterogeneous agriculture areas	77 Scattered fruit trees 17 Groves, hedges 18 Clusters of trees (on agricultural areas) (partially) 13 Open forest (on agricultural areas) (partially)
3. Forest and semi-natural areas	3.1 Forests	11 Normal dense forest 14 Forest stripes, edges
	3.2 Shrub and/or herbaceous vegetation associations	10 Other forest 12 Open forest (on unproductive areas) 13 Open Forest (on agricultural areas) (partially) 15 Brush forest 16 Scrub vegetation 18 Clusters of trees (on agricultural areas) (partially) 85 Mountain meadows 86 Brush alpine pastures 87 Remote and steep alpine meadows and pastures 88 Favourable alpine pastures 89 Rocky alpine pastures
	3.3 Open spaces with little or no vegetation	97 Unproductive grass and shrubs 99 Bare land
4. Wetlands	4.1 Inland wetlands	95 Wetlands 96 Water shore vegetation
	4.2 Coastal wetlands	
5. Water bodies	5.1 Inland waters	91 Lakes 92 Rivers 69 River shores
	5.2 Marine waters	
Fictive Code 60		19 Other woods 20 Ruins

3.3.1 Agricultural areas

Within the context of agricultural areas uncertainties existed in the assignment of the alpine areas. In Switzerland they are included in the main category of Agricultural areas, whereas in CORINE Land Cover they are defined as Natural grassland (3.2.1) within the land use type Shrub and/or herbaceous vegetation associations (3.2) and under the main heading type of Forests and semi-natural areas (3.).

This difference leads to the problem of forested agricultural areas, which are defined in both regions in the Swiss Land Use Statistics without further differentiation. For the assignment of the Swiss Land Use Statistics base categories 13 and 18 to CORINE Land Cover types 2.4 or 3.2, information about the surrounding area using neighbourhood analysis routines had to be included. If the examination of any of the surrounding sample points yielded a majority usage in the Swiss Land Use Statistics base categories 71–84, then CORINE Land Cover type 2.4 was assigned. Similarly, a majority in Swiss Land Use Statistics base categories 85–89 justified the assignement to CORINE Land Cover type 3.2.

Categories 77 (Scattered fruit trees) and 17 (Groves, hedges) posed special questions. These were assigned to CORINE Land Cover type 2.4 (Heterogeneous agricultural areas) because the listed Swiss Land Use Statistics base categories correspond best to this type when an accumulated occurrence exists. During the process it became apparent that a spatial accumulation of many categories was a requirement for persistence through the spatial generalization processes. CORINE Land Cover type 2.4 could, in fact, not be ascertained using the sample point interpretation method. It is nevertheless suspected that the extent of this category in Switzerland has been largely underestimated.

3.3.2 Forested areas

Within the context of forested areas uncertainties arose regarding the assignment of shrub forests which only exist in alpine areas (stands of *Alnus viridis* or *Pinus mugo*). By analogy, using the Mediterranean Maquis and Garrigues formations, these areas should be assigned to CORINE Land Cover type 3.2 Shrub and/or herbaceous vegetation associations.

No satisfactory solution has been found for the assignment of the Swiss Land Use Statistics base categories 19 (Other woods) and 20 (Ruins – which are mostly but not always decaying alpine agricultural buildings). Since these two small area usages can occur in any environment, a meaningful translation into a CORINE Land Cover type was not possible. For this reason, a fictive CORINE Land Cover type 60 (unassigned codes) was created which accounts for a total of 38,962 sample points in the base data set.

The definitive assignment of type 60 followed in a spatial generalization of the base data set to the definite data sets (Section 4.2.1).

3.4 Results: The CORINE base data set

As a result of the outlined process, a CORINE base data set for Switzerland was derived which corresponds with the spatially identical data set of the Swiss Land Use Statistics and, except for the fictive code 60, with Level 2 nomenclature of CORINE Land Cover (Figure 3.4). This data set marked the starting point for a spatial generalization process which should produce two data sets not only thematically but also spatially compatible with CORINE Land Cover. In addtion, this base data set also serves as basis for analysis of area statistics (Table 3.4).

Fig. 3.4 The CORINE Land Cover base data set (aggregated) **Area of Interlaken 1:100,000**

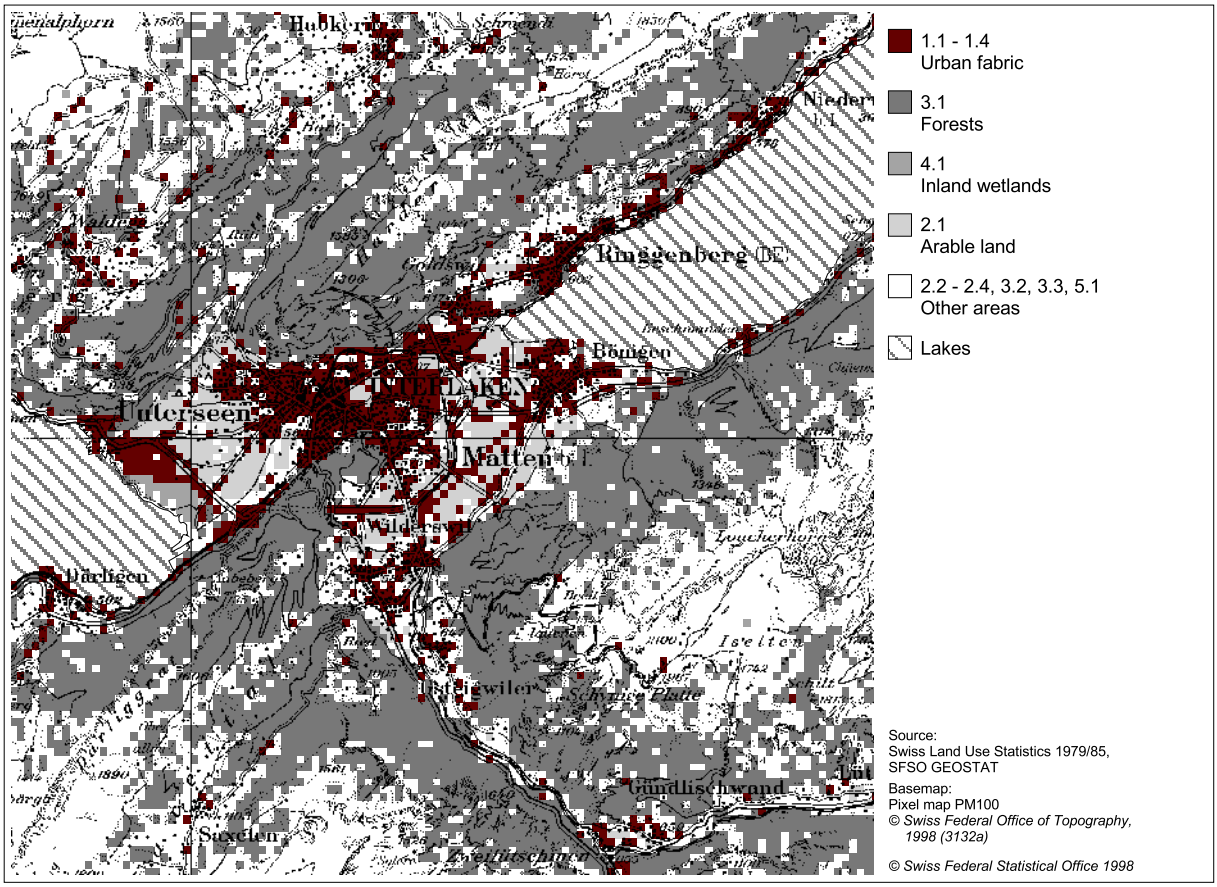


Table 3.4 Swiss Land Use Statistics 1979/85 adapted for CORINE Land Cover

Canton	Corine Land Cover-Code													Area in hectares
	1.1	1.2	1.3	1.4	2.1	2.2	2.3	2.4	3.1	3.2	3.3	4.1	5.1	6.0
ZH	15,702	12,057	1,566	2,239	40,577	1,906	32,192	6,329	49,433	447	41	1,007	8 498	877
BE	16,750	13,417	1,942	1,595	70,581	995	97,220	14,721	154,631	109,352	92,366	784	17,411	4,322
LU	5,061	4,317	599	489	25,212	866	45,271	7,788	39,076	10,251	2,017	243	7,345	806
UR	560	857	141	42	578	8	5,080	654	11,792	32,123	51,602	29	3,113	1,079
SZ	1,842	1,795	268	136	3,234	218	18,328	2,857	25,767	18,044	9,816	373	6,934	1,221
OW	566	593	112	47	1,267	27	5,636	1,127	15,999	14,990	6,331	199	1,721	435
NW	509	505	95	45	555	14	4,590	743	7,682	6,274	2,718	24	3,645	213
GL	718	710	84	44	787	9	5,447	735	14,780	20,583	22,236	19	1,624	734
ZG	1,130	1,020	225	126	3,298	268	6,692	1,191	6,073	178	18	245	3,296	119
FR	4,782	3,968	851	483	44,351	299	32,406	4,037	38,623	22,129	4,696	453	9,081	922
SO	4,386	3 175	448	402	17,348	268	12,261	3,572	32,027	4,033	65	12	641	429
BS	1,380	876	38	326	200	36	176	74	431	3	0	0	151	15
BL	3,852	2,826	424	458	7,230	620	10,777	3,627	20,154	1,178	9	3	247	342
SH	1,319	1,247	185	167	8,162	559	4,667	662	12,339	77	3	44	325	96
AR	941	646	48	45	1,184	8	10,754	1,006	7,278	1,919	172	4	97	185
AI	304	257	18	11	491	1	5,791	395	4,431	4,127	1,171	4	141	109
SG	7,522	6,299	775	696	19,231	870	47,642	8,613	49,372	36,498	13,030	368	9,816	1,822
GR	4,435	5,450	772	506	3,380	512	40,257	6,243	116,047	248,850	264,994	378	9,750	8,971
AG	9,799	7,263	1,123	777	34,054	1,280	26,742	6,906	48,353	141	22	137	2,961	805
TG	4,616	4,070	449	403	29,518	2,976	17,769	5,396	19,644	119	10	205	13,568	355
TI	6,489	4,331	745	552	2,631	1,278	8,982	2,763	97,683	75,022	62,352	139	12,241	6,040
VD	11,418	9,264	1,364	1,342	71,136	5,167	34,625	6,936	86,628	40,347	10,551	816	40,167	1,418
VS	5,456	5,833	1,076	583	3,865	8,433	22,394	6,714	80,311	110,457	263,740	133	6,522	6,939
NE	2,697	1,951	237	357	5,919	723	16,508	2,262	27,563	12,501	99	205	8,933	351
GE	4,405	2,283	394	575	8,076	1,615	2,489	1,214	2,940	92	13	19	4,034	73
JU	1,948	1,430	138	103	15,867	35	12,331	3,060	33,719	14,119	259	63	282	284
Total	118,587	96,440	14,117	12,549	418,732	28,991	527,027	99,625	1002,776	783 854	808,331	5,906	172,544	38,962

4 The spatial generalization process of the base data set

4.1 Problem analysis

In order to construct a grid and a polygon data set for the correlation of the Swiss Land Use Statistics with CORINE Land Cover, the newly created CORINE base data set, which was defined by point information that still allows for small areas and linear elements, was subjected to a spatial generalization. The minimum mapping units of a CORINE Land Cover compatible data set needed to be taken into account to define such a generalization procedure. For the grid data set this requirement was a unit size of 250×250 m (European Environmental Agency standard), for the polygon data set this was a minimum area size of 25ha. The transformation of the orignal hectare information into spatial units corresponding to CORINE Land Cover needed to be transparent and reproducible.

The spatial generalization process occurred in each hectare independent of the actual information on land use and led to a serious misrepresentation of surface area statistics. For this reason, information presented in Section 4.4 regarding the base data set should be unconditionally heeded.

4.2 The CORINE grid data set

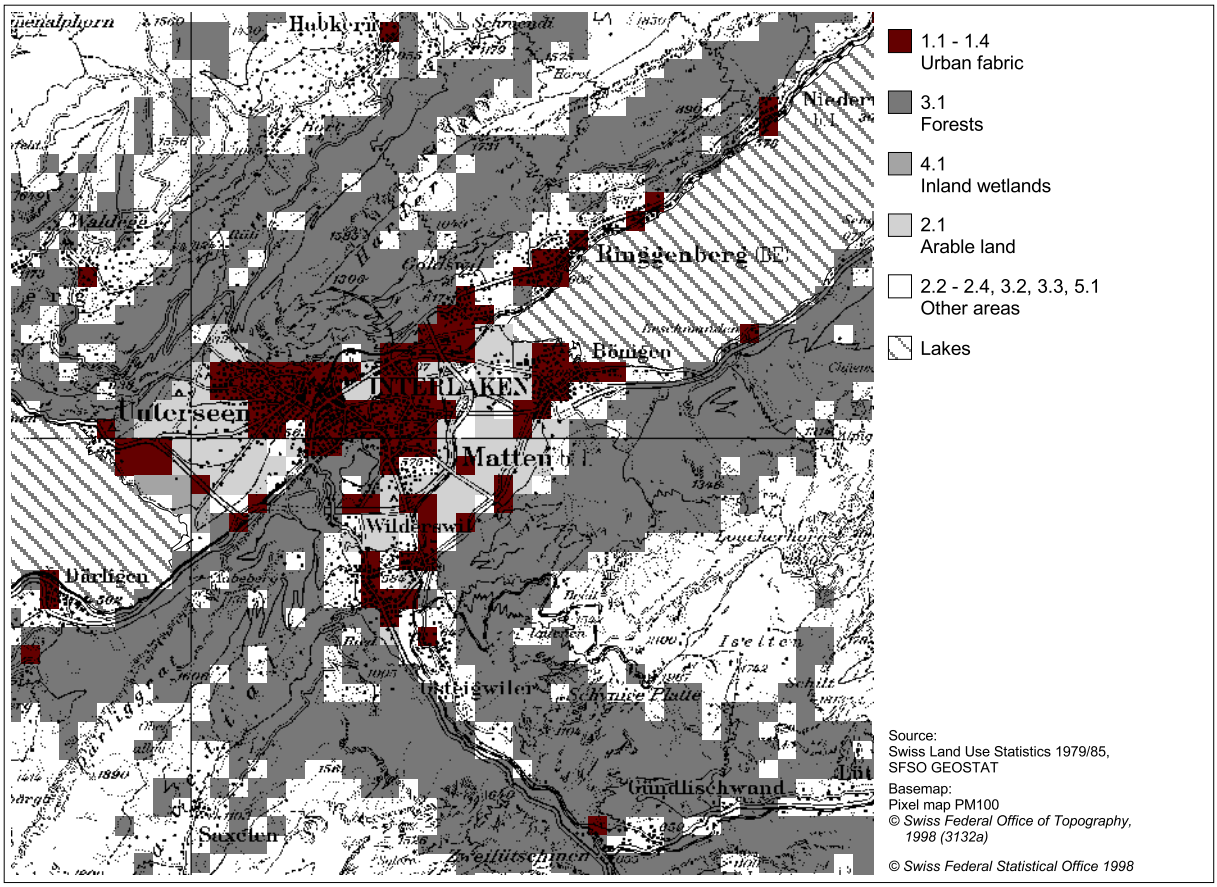
4.2.1 Spatial modelling

Using the base data set as a starting point, the grid data set (with a grid size of 250 m) was generated as follows:

- Conversion of grid units to polygons.
- All polygons in Class 60 (defined in the base data set as unassigned code) were assigned the code of the neighbouring polygon which shares the longest common boundary.
- This polygon cover was reconverted into a grid data set with a cell size of 50 m.
- Finally, a resampling to the required 250 m grid cell size, in which each block contains 25 cells, was carried out. The resulting attribute value (land cover code) was determined by the prominent attribute value within the 25 cells. When more than one value appeared prominent, no resulting attribute value was assigned (‘holes’)
- ‘Holes’ were eliminated by investigating successive neighbouring clusters around the focal cell (in the 50 m grid data set) until an appropriate resulting attribute value could be assigned to every cell.

The correspondent ARC/INFO commands for these tasks are listed in the appendix.

Fig. 4.2.1 The CORINE Land Cover grid data set (aggregated) **Area of Interlaken 1:100,000**



4.2.2 Technical specifications

The resulting grid data set contains a total of 664,338 cells of 250×250 m and consequently corresponds to an area of 4,152,112.5 ha.

Table 4.2.2 Comparison of base and grid data sets for CORINE Land Cover at Level 2

CORINE Land Cover groups	Grid data set		Base data set
	No. of cells	No. of hectares	No. of hectares
1.1 Urban fabric	17,460	109,125	118,587
1.2 Industrial, commercial and transport units	6,994	43,712	96,441
1.3 Mine, dump and construction sites	1,153	7,206	14,117
1.4 Artificial non-agricultural vegetated areas	1,092	6,825	12,549
2.1 Arable land	78,284	489,275	418,732
2.2 Permanent crops	4,011	25,068	28,991
2.3 Pastures	91,547	572,168	527,028
2.4 Heterogeneous agriculture areas	4,777	29,856	99,625
3.1 Forests	173,918	1,086,987	1,002,781
3.2 Shrub and/or herbaceous vegetation associations	131,783	823,643	783,855
3.3 Open spaces with little or no vegetation	127,435	796,468	808,331
4.1 Inland wetlands	612	3,825	5,908
5.1 Inland waters	25,272	157,950	172,564
6.0 No assignment			38,962
Total	664,338	4,152,108	4,128,471

The overall area of Switzerland is thereby enlarged around 0.6% over the base data set value, which can be explained by the increase in grid cell size from 100 m to 250 m. The actual borders of Switzerland appear to be expanded (while those of neighbouring state exclaves inside Switzerland decrease).

Generalization using the majority weighting procedure has a tendency to expand categories which favour large areas. For example it is highly probable that, with the occurrence of category 5.1 Inland waters inside a block of 25 cells of the base data set, this category will dominate other small area uses.

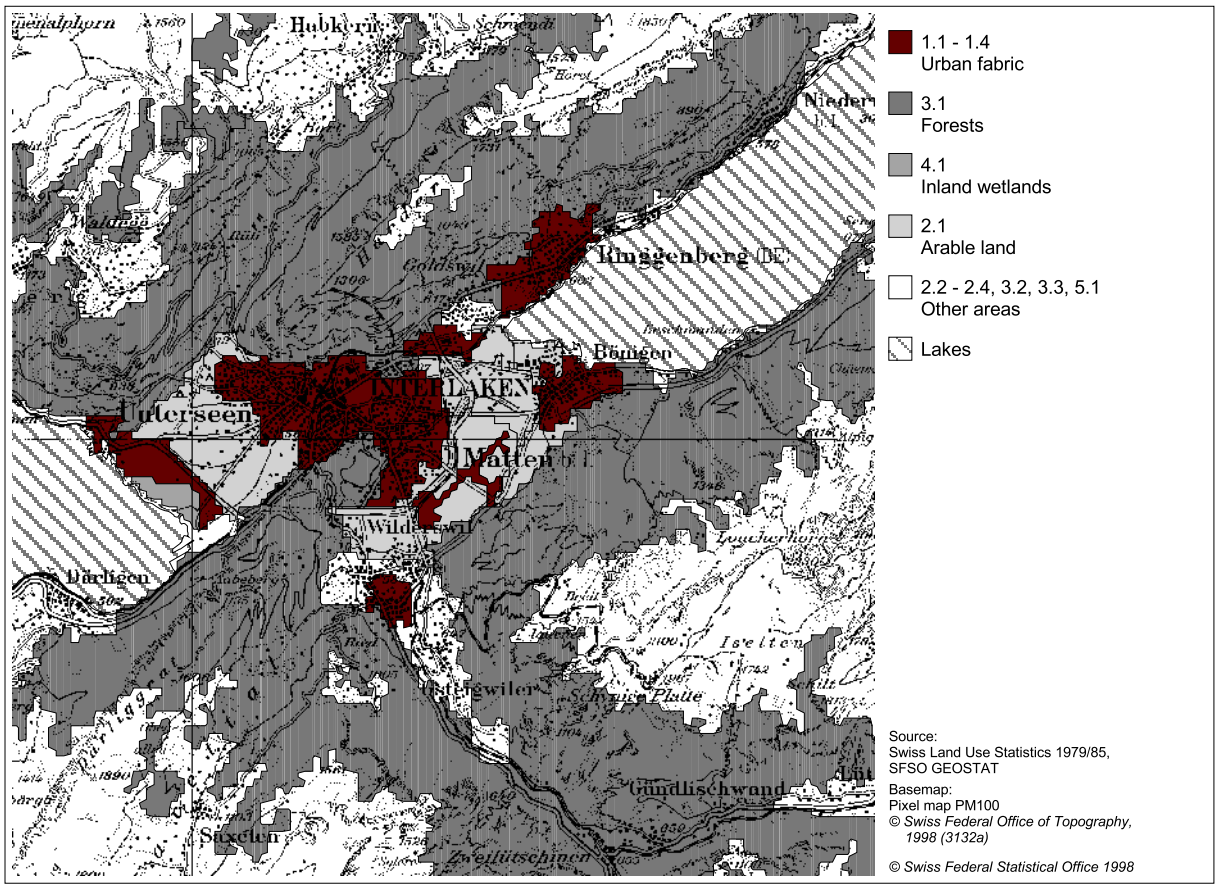
4.3 The CORINE polygon data set

4.3.1 Spatial modelling

Using the base data set as a starting point, the polygon data set (with a minimum area size of 25ha) was generated as follows:

– Refining the base data set to a grid of 25 m cell size using a C-routine to bevel corners of the original grid. With this, two goals were reached. On the one hand, the subsequent conversion to polygons could be carried out without inheriting the grid structure of the base data set. On the other hand, the elimination of linear structures was minimized. Such structures, if diagonally oriented, tend to be broken down into small single polygons endangered to be omitted in the following generalization process.

Fig. 4.3.1 The CORINE Land Cover polygon data set (aggregated) **Area of Interlaken 1:100,000**



– The 25m grid data set was converted into polygons using a weed tolerance of 20m, i.e. not all corners of the grid were considered to become polygon vertices. All polygons in class 60 (defined in the base data set as unassigned code) were assigned the code of the neighbouring polygon which shared the longest common boundary.

– Polygons with an area less than 25 ha were eliminated, again using the criteria of the longest common boundary. This procedure was reiterated three times (for less than 5 ha, less than 10 ha, and less than 25 ha) so that small area categories could better be maintained in the resulting data set.

The correspondent ARC/INFO commands for these tasks are listed in the appendix.

4.3.2 Technical specifications

The polygon cover comprises 13,542 polygons exhibiting an overall area of 4,127,959 ha. The assignment of polygons into individual categories was carried out as follows:

Table 4.3.2 Comparison of base (grid) and polygon data sets for CORINE Land Cover at Level 2

CORINE Land Cover groups	Polygon data set		Base data set
	No. of polygons	No. of hectares	No. of hectares
1.1 Urban fabric	17,460	97,364	118,587
1.2 Industrial, commercial and transport units	6,994	25,598	96,441
1.3 Mine, dump and construction sites	1,153	1,812	14,117
1.4 Artificial non-agricultural vegetated areas	1,092	2,548	12,549
2.1 Arable land	78,284	521,636	418,732
2.2 Permanent crops	4,011	21,725	28,991
2.3 Pastures	91,547	568,682	527,028
2.4 Heterogeneous agricultural areas	4,777	5,224	99,625
3.1 Forests	173,918	1 128,198	1,002,781
3.2 Shrub and/or herbaceous vegetation associations	131,783	820,493	783,855
3.3 Open spaces with little or no vegetation	127,435	778,387	808,331
4.1 Inland wetlands	612	1,998	5,908
5.1 Inland waters	25,272	154,286	172,564
6.0 No assignment			38,962
Total	664,338	4,127,951	4,128,471

The overall area loss (almost 500 ha) as compared to the base data set can be explained on the one hand by the generalization along the national boarder (weed tolerance of 20m). On the other hand, some polygons smaller than 25ha were assigned to neighbouring countries (i.e. *NODATA*) when no other dominant category could be found in their immediate neighbourhood. The latter could be avoided by using the ARC/INFO command *ELIMINATE* with the parameter *KEEPEDGE*.

4.4 Surface area analysis

Whichever procedure is used during generalization of point or grid data, it is inevitable that the area statistics will change. Generalized data are secondary data which means that the percentage of each individual usage is no longer accurate in the results. As expected, the area of dominant usages (forests, arable land) increased while the areas of small scale and linear elements (industry, commercial and transportation land) massively decreased (Table 4.4).

Users of both Level 2 CORINE Land Cover compatible data sets should be aware of these variations in area statistics. Especially with the transfer of data into a geographical information system which admits area statistics with low effort, there exists the risk that area statistics will be derived from imprecise secondary data. Generalized data sets should be used, therefore, exclusively for cartographic purposes, while the base data set should be utilized for surface area statistics.

Table 4.4 Swiss Land Use Statistics 1979/85: correspondence with CORINE Land Cover (Level 2)

Surface area statistics: absolute areas

Areas in hectares	CORINE base data set Point raster 100 x 100 m	Raster data set 250 x 250 m	Polygon data set Minimum area 25 ha
1.1 Urban fabric	118,587	109,125	97,364
1.2 Industrial, commercial and transport units	96,441	43,712	25,598
1.3 Mine, dump and construction sites	14,117	7,206	1,812
1.4 Artificial non-agricultural vegetated areas	12,549	6,825	2,548
2.1 Arable land	418,732	489,275	521,636
2.2 Permanent crops	28,991	25,068	21,725
2.3 Pastures	527,028	572,168	568,682
2.4 Heterogeneous agricultural areas	99,625	29,856	5,224
3.1 Forests	1,002,781	1 086,987	1,128,198
3.2 Shrub and/or herbaceous vegetation associations	783,855	823,643	820,493
3.3 Open spaces with little or no vegetation	808,331	796,468	778,387
4.1 Inland wetlands	5,908	3,825	1,998
5.1 Inlands waters	172,564	157,950	154,286
6.0 No assignment	38,962		
Total	4,128,471	4,152,108	4,127,951

Surface area statistics: percentage of total area

Areas in %	CORINE base data set Point raster 100 x 100 m	Raster data set 250 x 250 m	Polygon data set Minimum area 25ha
1.1 Urban fabric	2.87%	2.63%	2.36%
1.2 Industrial, commercial and transport units	2.34%	1.05%	0.62%
1.3 Mine, dump and construction sites	0.34%	0.17%	0.04%
1.4 Artificial non-agricultural vegetated areas	0.30%	0.16%	0.06%
2.1 Arable land	10.14%	11.78%	12.64%
2.2 Permanent crops	0.70%	0.60%	0.53%
2.3 Pastures	12.77%	13.78%	13.78%
2.4 Heterogeneous agricultural areas	2.41%	0.72%	0.13%
3.1 Forests	24.29%	26.18%	27.33%
3.2 Shrub and/or herbaceous vegetation associations	18.99%	19.84%	19.88%
3.3 Open spaces with little or no vegetation	19.58%	19.18%	18.86%
4.1 Inland wetlands	0.14%	0.09%	0.05%
5.1 Inland waters	4.18%	3.80%	3.74%
6.0 No assignment	0.94%		
Total	100.0%	100.0%	100.0%

Surface area statistics: percentage in proportion to base data

Areas in %	CORINE base data set Point raster 100 x 100 m	Raster data set 250 x 250 m	Polygon data set Minimum area 25 ha
1.1 Urban fabric	100.0%	92.02%	82.10%
1.2 Industrial, commercial and transport units	100.0%	45.33%	26.54%
1.3 Mine, dump and construction sites	100.0%	51.04%	12.84%
1.4 Artificial non-agricultural and vegetated areas	100.0%	54.39%	20.30%
2.1 Arable land	100.0%	116.85%	124.58%
2.2 Permanent crops	100.0%	86.47%	74.94%
2.3 Pastures	100.0%	108.57%	107.90%
2.4 Heterogeneous agricultural areas	100.0%	29.97%	5.24%
3.1 Forests	100.0%	108.40%	112.51%
3.2 Shrub and/or herbaceous vegetation associations	100.0%	105.08%	104.67%
3.3 Open spaces with little or no vegetation	100.0%	98.53%	96.30%
4.1 Inland wetlands	100.0%	64.74%	33.82%
5.1 Inland waters	100.0%	91.53%	89.41%
6.0 No assignment	100.0%	0.00%	0.00%
Total	100.0%	100.57%	99.99%

5 Conclusions

Through Switzerland's contribution to CORINE Land Cover an "information hole" in the centre of Europe could be closed before the end of 1997. It appears that, by the end of the 20th century, the goal of the CORINE programmes – a unified European information base – can be widely reached. Thus it is timely for a few comments on the future of CORINE Land Cover and its desired updating.

As mentioned at the beginning of this report, it is assumed that with the increasing advent of digital remote sensing, a convergence of the 44 classes in CORINE Land Cover and presently 74 categories of the Swiss Land Use Statistics 1992/97 is more and more likely. The forest differentiation project using Landsat TM data, which is being carried out under the framework of methodology development for the Swiss Land Use Statistics, is an important step in this direction (SWISS FEDERAL STATISTICAL OFFICE 1996). Another step would be the differentiation between arable land and permanent pastures (again using satellite data), although cost efficiencies have to be examined considering the frequent crop rotation in the Swiss agriculture. This way, the feasibility for implementation of CORINE Land Cover Level 3 in Switzerland by avoiding the earlier mentioned inaccuracies becomes more apparent.

Concerning CORINE Land Cover, it is hoped that a follow-up programme on the part of the European Union will occur. Specifically, changes in land use can only be comprehended and assessed for their actual repercussions when results from follow-up investigations are available. As far as national interests and the responsibility of the member states are concerned, it is hoped that future land cover and land use surveys will use compatible data sources and methods in order to guarantee comparability with the present data.

Both the Swiss Federal Statistical Office (SFSO) and the Swiss Agency for the Environment (SAEFL), which have been involved on behalf of Switzerland in the compilation of these European compatible data, look forward to a continued fruitful co-operation with the EU and other international institutions working in the fields of environmental data, geographical information science and remote sensing. In order to effectively address changes in environmental as well as structural framework conditions, rapidly available and reliable base information is increasingly required. It is in the common interest of all concerned to successfully master these problems.

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7 Appendix

Procedure for generation of the grid data set in ARC/INFO commands (schematic):

```
GRIDPOLY clcbn85b clcbn85b_poly .1                          /* Conversion to polygons
ELIMINATE clcbn85b_poly clcbn85b_ohne60 # # code60          /* Elimination of category 60
POLYGRID clcbn85b_ohne60 c_raster50 grid-code               /* Conversion to 50m grid

c_raster50_maj = BLOCKMAJORITY(c_raster50,rectangle,5,5)    /* Dominant value in a 5×5-block ...
c_raster250 = RESAMPLE(c_raster50_maj,250)                  /* … will be assigned in the 250m grid

loecher = CON(ISNULL(c_raster250),1)                        /* Filtering of ”holes”

/* ”Holes” will be eliminated successively by inheriting the values of the central cells of the following
   data sets:

foc_rect_7 = FOCALMAJORITY(c_raster50,rectangle,7,7)        /* 7×7 block (eliminates 7695 holes)
foc_rect_9 = FOCALMAJORITY(c_raster50,rectangle,9,9)        /* 9×9 block (eliminates 512 holes)
foc_circ_3 = FOCALMAJORITY(c_raster50,circle,3)             /* circle, r = 3 (eliminates 36 holes)
foc_rect_3 = FOCALMAJORITY(c_raster50,rectangle,3,3)        /* 3×3 block (eliminates 12 holes)

/* The last remaining hole is assigned a value manually (constellation refuses any logical neighbourhood
     analysis)

clcbn85g = MERGE(c_raster250, ...)                          /* Merging of the partial results
```

Procedure for generation of the polygon data set in ARC/INFO commands (schematic):

```
clcbn85b_25 = RESAMPLE(clcbn85b,25)                         /* Resampling to 25m
clcbn85b_25_plus = GRID16(clcbn85b_25)                      /* GRID16: C-programme;
                                                            /* Bevel corners
GRIDPOLY clcbn85b_25_plus clcbn85p_all 20                   /* Conversion to polygons with a weed
                                                               tolerance of 20m

ELIMINATE clcbn85p_all clcbn85p_gt0 # # code60              /* Elimination of category 60
ELIMINATE clcbn85p_gt0 clcbn85p_gt5 # # area_lt5            /* Elimination of polygons less than 5ha
ELIMINATE clcbn85p_gt5 clcbn85p_gt10 # # area_lt10          /* Elimination of polygons less than 10ha
ELIMINATE clcbn85p_gt10 clcbn85p # # area_lt25              /* Elimination of polygons less than 25ha;
                                                            /* Result: clcbn85p
```

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Reference for CORINE Land Cover compatible data for Switzerland:
Swiss Federal Statistical Office, GEOSTAT, 2010 Neuchâtel, Tel: 032 713 64 11, E-Mail: geostat@bfs.admin.ch

Until now there has been no land cover data for Switzerland which was compatible with European classifications. This deficiency has now been eliminated by the Swiss Federal Statistical Office (SFSO) and the Swiss Agency for the Environment (SAEFL).

This brochure describes the methods and data sets which have been used during the integration of the Swiss Land Use Statistics into the system used for the CORINE Land Cover classification within the European Union.

During these operations the base data set of the Swiss Land Use Statistics 1979/85 was reclassified and spatially generalized to correspond with categories at Level 2 of CORINE Land Cover using an existing digital soil suitability map as a further modelling background. With the help of a geographical information system a grid data set with 13 land cover categories was generated from which corresponding polygonal data has been derived.

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