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"History of hot spots - assessment"

THE HISTORY OF SALT LAKES IN THE SEEWINKEL – A THREATENED NATURAL HERITAGE IN THE PROJECT REGION CENTRAL SOUTH

Anna Hermann, Michael Kuttner, Martin Prinz, Christa Renetzeder, Stefan Schindler, Sonja Völler, Iris Wagner, Thomas Wrbka, Katharina Zmelik,

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Summary

Introduction: Modern conservation strategies need a state of the art documentation of not only recent but also historical trajectories of landscape change, especially in areas where different land use demands like nature conservation, tourism and intensive agriculture compete over the same area. The Neusiedlersee-Seewinkel Nationalpark and its surroundings have been chosen for detailed investigations, focussing shallow soda lakes as they represent areas of outstanding biodiversity especially concerning migrating birds and salt adapted plants.

Objectives: The development of former common salt lakes in the Seewinkel which are located in the TransEcoNet project region Central South should be displayed. These landscape elements play an important role as stepping stones especially for wetland species migrating to the large fen areas in Hungary on the east side of the border.

Methods: Analysed parameters were size and distribution of the lakes for providing basic figures. A multi-temporal approach additionally showed the transformation into different land cover/ land use-classes by calculating a transition matrix. Therefore, basic historical data have been sheets of the 1st and 2nd Military Surveys of the Austrian-Hungarian monarchy, sheets from the Franciscean Cadastre and interpretated orthophotos from 1957. Current data were derived from the digital cadastral-map and land cover-data.

Results: Analysis showed a decrease in area of important natural and semi-natural habitats in general and especially for shallow salty lakes. In the study area the overall surface of these lakes decreased from approximately 1600 ha in 1780 to approximately 600 ha in 2004. The same trend concerning median area (14.1 to 1.6 ha) and distance between shallow salty lakes (5.2 to 4.6 km) could be observed. Main destination land use/cover category for former shallow salt lakes was "pastures and meadows". Less important were "arable land" and "artificial water courses".

Conclusions: The former quadrinominal field-grassland-fen-water-landscape has changed to a crop-viticulture-landscape but still remnants of the former landuse are present. For a possible hydrological restoration going hand in hand with an establishment of a transboundary ecological network basic elements and conditions are given.

1 Introduction

Landscapes can be defined as "spatially explicit ecosystems", thus reflecting best the interactions between natural and cultural processes. For a better understanding of recent developments, an investigation of landscape structure at different points in time is an appropriate and widely used approach method for displaying changes in this composition (Baudry, 1989; Buergi et al., 2004; Haber, 2004; Naveh, 1995). This change has always been, as it is typical for most landscapes, a slowly ongoing process which can often only be seen by comparing data from different centuries.

Land-use change as part of the overall landscape change has been shown as an important driver for biological impoverishment, especially in European agricultural landscapes and especially since the Second World War (e.g. Abensperg-Traun et al., 2004; Robinson & Sutherland, 2002).

In times of rapidly changing land-use systems caused from intensification and unification, connected with biodiversity loss and climate change, it is necessary and helpful to know how landscapes were built up in former times. Knowledge of the potential of a particular part of a landscape makes it possible to develop potential scenarios for the future (Antrop, 2004, 2005). Therefore, modern conservation strategies need state of the art documentation of not only recent but also historical trajectories of landscape change, especially in areas where different land-use demands compete over the same area.

Therefore this kind of analysis was feasible because of existing maps of the Military Surveys (MS) from the 18th and 19th century and local data, so called "Riedübersichtspläne" from the year 1856 (Dick et al., 1994).

In the frame of this survey we wanted to display the change in shallow salt lake (SL) extent during the last 250 years and its current land-use/land cover (LUC) with regard to a possible establishment of a transboundary ecological network along the Austrian - Hungarian border. In times of ecological restoration and of initialisation of ecological networks, stepping stones are needed to fill up ecological and biogeographical gaps. For this purpose potential areas needed to be found or defined. Improvement in understanding the land-use/land cover change (LUCC) will make it easier to work out possibilities for future network developments as targeted here in the project region Central South.

2 Study area

The study area, the so-called "Seewinkel" is a small part of the federal state Burgenland (Austria) situated east of Lake Neusiedl. In the south and east it forms the border to Hungary and enters the so-called "Waasen" (Hungarian: Hanság), a former large-scale fen area of large extent (approximately 450 km^2).

At 114 m a.s.l. it is the absolute lowest part and one of the driest parts of Austria with an average annual precipitation less then 600 mm per year (ZAMG, 2002). Bedrock is dominated by gravel and loam and, following modern soil typology (WRB, 2006), main soil types are different kinds of Chernozem and salt-influenced soil types like Solonchak or Solonetz (Haeusler, 2006; Löffler, 1982; Nestroy, 2005).

Unique for this area is the appearance of temporary shallow salty lakes (Berger et al., 1992; Löffler, 2000). These soda ponds are drainage-free (endoheric) and have an average depth between 30 and 80 cm and their water surface covers up to two square kilometres. The concentration of salts in the ponds can vary due to seasonal fluctuations of the water level, which is mainly depending on the amount of precipitation and evaporation (Dick et al., 1994; Krachler, 1992; Stojanovic et al., 2009). All hydrological unaffected soda lakes dry completely during summer months to salty swamps or desert-like areas covered by a salt-crust. The time and duration of drying out depends on amount of rainfall in late winter and during spring and of the evaporation rate during summer. The reason for this lies in the sealing function of the sodium salt when the substrate is water-logged. A declining groundwater table, whether over seasons or years forces the sodium salt substrate to dry out and the water impermeable horizons becomes crumbly and permeable (Knie, 1958).

In former times, the grassy steppe around these lakes allowed for extensive stock-breeding (especially cattle and horses). Concerning land-use this area is actually divided in to mostly small-scale agriculture comprising of a tourism influenced western part and a rather intensive agricultural used eastern part.

3 Methods

Interpretation of historical maps from the 18th and 19th century was the basis for displaying change of SL area (Křováková & Brůna, 2007; Timár & Pišút, 2008; Timár et al., 2008). Two military maps, data from so called "Riedübersichtsplänen" and interpretation from historical areal photographs from 1957 deliver four historical insights into the LUCC of the SL area and five time points for alteration of SL area during the last 250 years:

(1) Sheets of the 1st Military Survey (MS), which was compiled between 1763 and 1785 for the Austro-Hungarian monarchy. The specific sheets covering the study area have been plotted in 1785 (Kretschmer & Riedl, 2008).

(2) Sheets of the 2nd MS (compiled 1821 – 1869, plotted in 1845). The quality of the sheets from this time varies considerably. All variations from high class colours to poor quality brown-coloured copies of the original and missing signatures occurred but remarkable differences in the content between the sheets were not serious and rather rare. It was difficult to replicate historically mapped data in to the modern GIS and fix coordinates, particularly for the 1st MS therefore through the use of ground control points assessments were made to geo-authenticate the maps. To increase precision of manual rectification an existing high-resolution laser-scan (LIDAR) was used for building up a digital terrain-model (DTM) with a horizontal resolution of 17 cm and 4 cm accuracy in height (Bitenc, 2007). Military surveys in general concentrate on military relevant land marks. In this special case, frequently plotted small observations knolls were accurately linked to uprisings in the DTM.

(3) Data from 1856 were taken from a project which used "Riedübersichtspläne" for displaying LUC. These historical data were collected especially to display extensively used wet meadows.

(4) Interpretation of black and white aerial photographs from the year 1957 within the same project has been used to display the change of lake areas (Dick et al., 1994). These are the only data with no information about surrounding LUC because only SL area was relevant for this investigation.

Current extension of the SLs was derived from the official lake layer (Amt der Burgenländischen Landesregierung, 2004). Current land cover data were taken from the official digital cadastral-map (DCM, which is constantly renewed) and SINUS land cover-data (Peterseil et al. 2003).

The study area was defined as the minimum extent of all 4 area-wide datasets (1786, 1845, 1856, 1957 and current data). It was restricted to a broad strip along the eastern shore of Lake Neusiedl to Hanság on the Hungarian border.

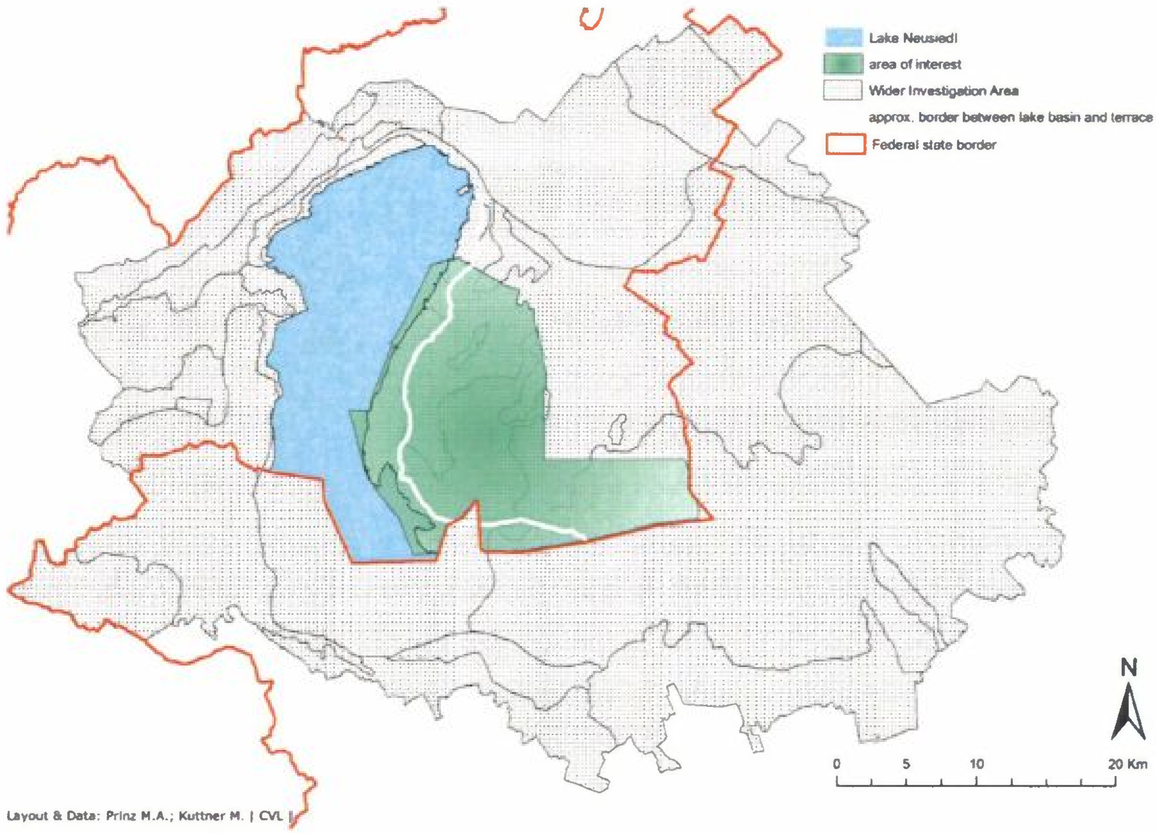

Figure 1 Study area within the Wider Investigation Area Central South

Figure 1 displays the extension of the study area which covers 271.9 km². Only SLs situated several meters above the lake basin on the terrace of the Seewinkel have been used for analysis, because of their completely different hydrology. Also existing SLs at the edge of Lake Neusiedl have not been taken into account, because their water level is mainly influenced by the water level of lake Neusiedl, whereas the water level of the SLs on the terrace are independently influenced by a separate ground water body.

Minimal mapping unit during interpretation of historical data represent the particular smallest visible structure. Their universally applicable attributes meant that the basis for interpretation of area-wide LUC were the attributes of the CORINE-Land cover classification (Bossard et al., 2000) with some extensions based on the Hungarian CLC50-classification

(Büttner et al., 2004). Signatures used in the sheets were very comprehensive, especially from the 2nd Military Survey. Hungarian signatures were been translated into German to make interpretation easier. For details of interpretation see Prinz et al., 2010). Analysis was performed by geographical and thematic intersection of available LUC-data with the software package ArcGis 9.3 (ESRI, 2008) and the creation of a cross-tabulation matrix (Mottet et al., 2006; Pontius et al., 2004). Distances between SL-polygons were calculated using an Avenue script within ArcView 3.3 (Nicholas, 2008).

4 Results

The main changes that had occurred concerned the area of arable land which is actually two times larger than 1785. The greatest change concerned the area of viticulture. Historically viticulture was only small-scaled and scattered, but today's viticulture-area is 63-times bigger than in the 18th century. There has also been a sizeable loss of marshland over the centuries, only seven percent outlasted the last 200 years of intensification and drainage. Forest never played a role in this dry region. The total area of pastures and meadows changed just a little while water surface has also decreased down to half of the area that had been covered two centuries ago. For further details regarding the LUC see Prinz et al. (2010).

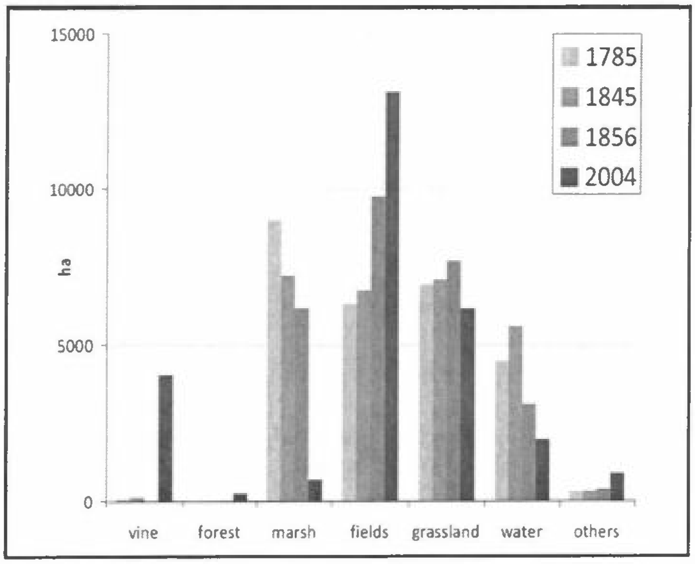

Figure 2 Changes of l land-use/land cover (LUC) from 1785 to 2004 in ha

Based on the maximum area of 1856, the remaining SL area is a lowly 28%. Fluctuations not only in area but also in geographic location and extent allow for calculation of maximum and minimum SL-area (see Tab. 1, Fig. 3). This means that maximal 3219.2 ha and minimal 363.1 ha have been covered by salt ponds. The number of SLs varies between 50 and 85, whereas median area decline per SL is at 1.6 ha until now (see Tab.1). Quartile data showed the same tendency in 2004 at 0.7 ha for the first quartile and 5.3 ha for the third quartile. Median edge to edge distance between SLs decreased to 4.4 km until 1957 but has been slightly increasing since then.

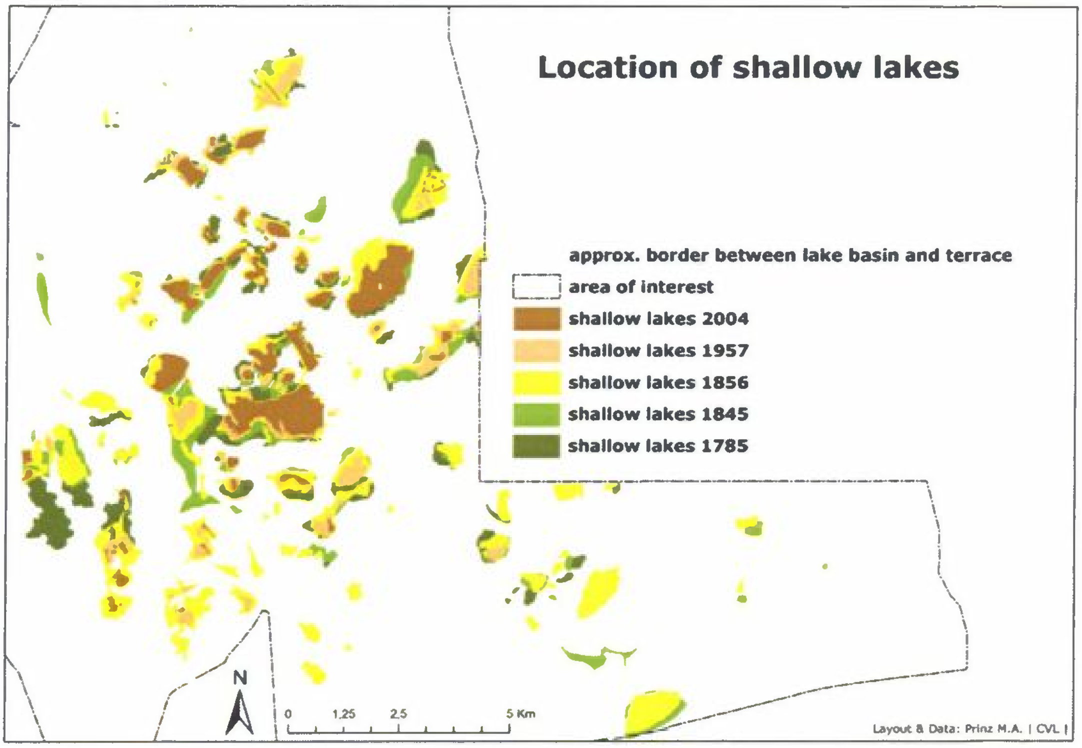

Figure 3 Extent and location of the shallow salt lakes in the study area Seewinkel from 1785 – 2004

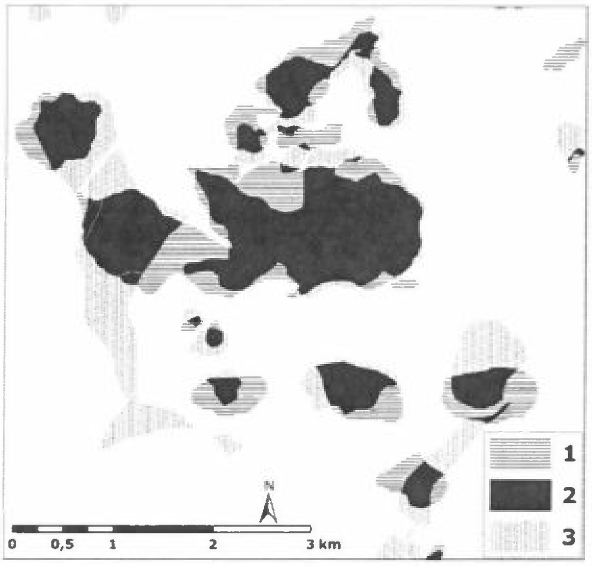

Figure 4 Example for categories of transition between two time points (particular detail of 1785 and 1845): (1) SL-area only in 1785; (2) SL-area in both time points, (3) SL-area only in 1845.

Because of this high fluctuation (Fig. 3) it is interesting to know the origin and the destination of SL area during history. When looking into details of the transition several results can be displayed:

Figure 4 shows an example how different SLs are distributed within two points in time in the central part of the study area. There are large parts covered by water only once, some others at all points of time. Figure 5 now tries to quantify these fluctuations:

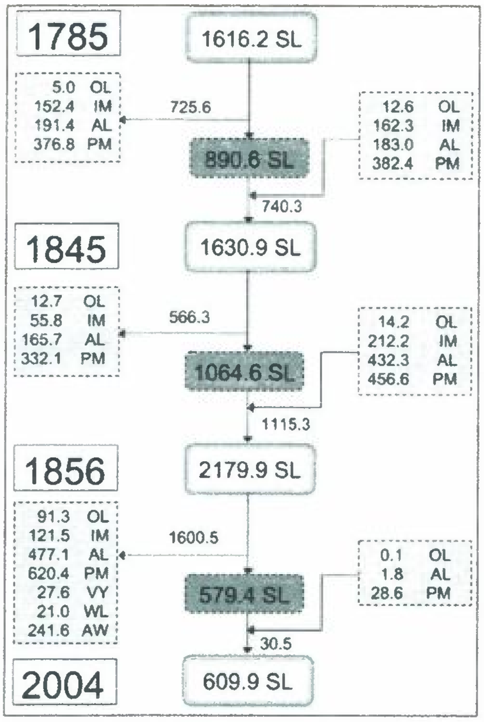

Figure 5: Transition of LUC-categories covering SL-area. Left side boxes displaying LUC-categories evolve from SLs, right side boxes displaying LUC-categories evolve to SLs. Central strand displays area covered by SLs. All figures in ha. Abbreviations: OL – other LUC; IM – inland marshes; AL – arable land; PM – pastures/meadows; VY – vineyards; WL – woodland; AW – artificial water basins and courses. Figures represent ha.

Based on the SL area from 1785, the development of SL to other LUC-categories and the origin of SL out of other LUC-categories are displayed. Loss of SL area was between 35 % (1845/1856) and 73 % (1856/2004), new evolved SL area was between 5 %(1856/2004) and 51 % (1845/1856). The most important sink and source for salt ponds was the LUC "pastures/meadows" (PM). Inland marshes (IM) and arable land (AL) also played an important role. More than 11 % of the natural SL area in 1856 have been altered tor drains and ditches, fish ponds and pools.

5 Discussion

5.1 *Thematic and spatial accuracy*

Crucial for comparing data are spatial and thematic consistency or at least similarity. When working with data of historical sources various problems may occur. Geographically correct positional arrangement of the interpreted data is essential for further processing. Data are only usable when certain accuracy-level is achieved. In this case accuracy was better than 20 meters in the central and most important part of the study area. Inaccuracies up to 200 m on the eastern margin of the study area had therefore no influence on transition matrix data. For problems during georeferencing and interpretation of maps and data see Prinz et al. (2010).

5.2 *LUC changes*

Dramatic loss of ecologically valuable areas was typical for decades and even centuries. Depending on the local situation changes were more or less serious. In this area, reasons for this big change in LUC are first and foremost the intensification of tillage. Therefore, one of the major requirements was the regulation of water level by drains and ditches (Draganits et al., 2006). An obvious marker for this development is the increasing area of "artificial water courses". Although this LUC has no signature in the analyzed historical maps, of course drains and ditches were present. But because of their adaption to local conditions, their existence created a positive additional ecological niche with small effect on hydrology of the surrounding. Effective draining did not start until the late 19th century (Löffler, 2000). Today's drains are much deeper and often made of concrete thus exceedingly affecting ground water level (Reitinger & Schmalfuss, 1992, 1993). But within the intensive farmland even this artificial structures provide resources for various ecosystem services (Herzon & Helenius, 2008).

5.3 *Development of shallow salt lakes*

Although loss of lake area in the last 50 years is not as dramatic as in the 100 years before (see tab. 1), the remaining biodiversity hot spots have become smaller and more isolated. Especially within the fen-area called Hansag and the Austrian-Hungarian border all former SL have completely disappeared. Only in central parts of the Seewinkel SLs can still be found. Statistics also illustrate shrinking and increasing isolation of SLs (Tab. 1 below). However this is not the case for the number of SLs, which is varying throughout time, but the decrease of median area reflects one severe problem. The ponds become smaller and smaller. Although more small conservation areas have a greater diversity then one large one (Higgs & Usher, 1980), in the long run undersized areas are far more problematic. Since MacArthur & Wilson (1967) it is widely known, that the probability of extinction of a species for smaller and isolated areas is much higher as for larger and closer ones.

Isolating tendencies can also be seen in the development of median distance between the SLs. Distance decreased until 1957 which can be interpreted with the loss of many peripheral SL and a centralisation process.

5.4 *Basis and evolution of shallow salt lakes*

Basically SL area declines when direct precipitation declines and vice versa. Principal parts of landuse-change took place between LUC "pastures and meadows" (25 % - 1785|1845, 20 % - 1745|1856, 28 % - 1856|2004) and the SLs. This is understandable due to the fact that marginal areas have always been first used as extensive pastures. Therefore this LUC category was also the main non-water source for SLs (23 % - 1785|1845, 21 % 20 % - 1745|1856, 5 % - 1856|2004).

"Arable land" was also prominently involved in SL transition (12 % - 1785|1845, 10 % - 1845|1856, 22% - 1856|2004). That change phenomenon especially happened when the SL had been formerly covered by freshwater or the SL soil desalinated. The proportion of area that had turned into "arable land" turned out highest between 1856 und 2004. This can be explained by improvements of agricultural land management (e.g. filling up of small depressions). The reconversion of "arable land" areas to SLs only took place at extensively used areas and has only relevance when looking back on historic changes (11 % - 1785|1845, 20 % - 1845|1856).

Accompanying the conversion to "arable land" is the rather recently illustrated conversion to "artificial water basins and courses". Effective drainage is a crucial point in gaining and intensifying farm land in a naturally wet area. Transformation into "inland marshes" on the other hand is a mainly natural process of non-agricultural areas, although siltation due to drawdown accelerates this development (9 % - 1785|1845, 3 % - 1845|1856, 5 % - 1856|2004). Elevation of groundwater on the other hand lead to an evolution of "inland marshes" (10 % - 1785|1845, 10 % - 1845|1856).

5.5 *Implications for nature conservation*

In the surroundings of the most western steppic lake in Europe the appearance and stability of shallow salt lakes are crucial for biodiversity and threatened species and communities (e.g. Dick, 1991; Eder et al., 1997; Metz & Forro, 1991; Wolfram et al., 1999; Zimmermann-Timm & Herzig, 2006; Zulka et al., 1997.)

The uniqueness of these shallow salty lakes in this area has also been delineated as a separate landscape character type (Konkoly-Gyuró et al.). Despite the fact, that these lakes can only be found on the Austrian side of the border to hungary, management of hydrology has to be performed on both sides. In this context the boundary-forming so-called "Einser-

Kanal", which was established in 1895 and having a length of approximately 16.5 km, has a great influence not only to the water level of the Neusiedlersee, but also to the SLs by regulating ground water level east of the Neusiedlersee.

Cereghino et al. (2008) point out the crucial part of ponds as stepping stones between freshwater ecosystems and this could be the case for the less saline SLs (Zulka & Milasowszky, 1998) that act as such stepping stones to large wetlands in the north (Leitha and Danube floodplains) and in the southeast (Hansag and Raab floodplain).

6 Conclusions

To conclude, the former quadrinominal field-grassland-fen-water-landscape has changed to a crop-viticulture-landscape but still remnants of the former extensive LUC system are present. In case of a probable extensification of agricultural areas on marginal sites in a changing regional economic system, these remnants could be a starting point of renaturation of parts of the area. However, an improvement of the hydrological situation with a centralized hydrological management system will be necessary for an effective and sustainable renaturation. Combining existing and potential areas with a hydrological management will be a first step for a re-establishment of these large and highly diverse landscapes between Austria and Hungary.

References

Abensperg-Traun, M., Wrbka, T., Bieringer, G., Hobbs, R., Deininger, F., Main, B.Y., Milasowszky, N., Sauberer, N., & Zulka, K.P. (2004). Ecological restoration in the slipstream of agricultural policy in the old and new world. *Agriculture Ecosystems & Environment, 103*, 601-611.

Amt der Burgenländischen Landesregierung. (2004). Lackenflächen.

Antrop, M. (2004). Landscape change and the urbanization process in Europe. *Landscape and Urban Planning, 67*, 9-26.

Antrop, M. (2005). Why landscapes of the past are important for the future. *Landscape and Urban Planning, 70*, 21-34.

Baudry, J. (1989). Interactions between agricultural and ecological-systems at the landscape level. *Agriculture Ecosystems & Environment, 27*, 119-130.

Berger, R., Fally, J., & Lunzer, H. (1992). Frischer Wind am Steppensee. Friedenspark im Herzen Europas. (p. 160). Deutschkreuz: Fally.

Bitenc, M. (2007). Analysis of airborne laser scanning data and products in the Neusiedler See Project. *Ekscentar, 10*, 60-64.

Bossard, M., Feranec, J., & Otahel, J. (2000). CORINE land cover technical guide – Addendum 2000. *Technical report No 40* (p. 105): EEA.

Buergi, M., Hersperger, A.M., & Schneeberger, N. (2004). Driving forces of landscape change - current and new directions. *Landscape Ecology, 19*, 857-868.

Büttner, G., Maucha, G., Bíró, M., Kosztra, B., & Petrik, O. (2004). National CORINE Land Cover mapping at scale 1:50.000 in Hungary. In: Umweltbundesamt (Ed.), *Workshop CORINE Land Cover 2000 in Germany and Europe and its use for Environmental Applications*. Berlin.

Cajthmal, L. (2006). Publishing Old Maps via the Internet: An Overview of Possibilities. *Wiener Schriften zur Geographie und Kartographie, 17*, 218-223.

Cereghino, R., Biggs, J., Oertli, B., & Declerck, S. (2008). The ecology of European ponds: defining the characteristics of a neglected freshwater habitat. *Hydrobiologia, 597*, 1-6.

Dick, G. (1991). On the spatial-distribution and social-organization of neck-banded greylag geese Anser anser in their breeding area of lake Neusiedl, Austria. *Ardea, 79*, 265-268.

Draganits, E., Zámolyi, A., Hodits, B., Gier, S., Grasemann, B., Janda, C., Schiel, B., Rohatsch, A., & Popp, F. (2006). Neusiedlersee/Fertö Tó area (Austria/Hungary): landscape change through time constrained by geomorphology, lithostratigraphic sections, archaeology and historical maps. *Geophysical Research Abstracts, 8*.

Eder, E., Hodl, W., & Gottwald, R. (1997). Distribution and phenology of large branchiopods in Austria. *Hydrobiologia, 359*, 13-22.

ESRI. (2008). ARCGIS 9.2.

Haber, W. (2004). Landscape ecology as a bridge from ecosystems to human ecology. *Ecological Research, 19*, 99-106.

Haeusler, H. (2006). The Parndorf- and Seewinkel gravel beds - implications of Middle Pleistocene uplift and neighboring subsidence in the Northern Burgenland (Austria). *Geophysical Research Abstracts, 8*, 2.

Herzig, A., Horvath, D., Kraus, K., & Naumann, K. (2001). Renaturalization of Parts of the National Park Neusiedler See Seewinkel/Fertö-Hansag by the Aid of Laser Scanning. *Proceedings of the Conference on GIS and Remote Sensing with special emphasis on Monitoring World Heritage Sites*. Sopron, Ungarn: University of West Hungary.

Herzon, I., & Helenius, J. (2008). Agricultural drainage ditches, their biological importance and functioning. *Biological Conservation, 141*, 1171-1183.

Higgs, A.J., & Usher, M.B. (1980). Should nature reserves be large or small. *Nature, 285*, 568-569.

Kirschner, A., Krachler, R., Krachler, R., & Korner, I. (2007). Renaturierung ausgewählter Lacken des burgenländischen Seewinkels. *Ein Projekt im Rahmen des „Österreichschen Programms für die Entwicklung des Ländlichen Raumes – Sonstige Maßnahmen"*.

Knie, K. (1958). Über den Chemismus der Wasser im Seewinkel, der Salzlackensteppe Österreichs. *Angewandte Chemie-International Edition, 70*, 475-475.

Konkoly-Gyuró, É. Tirászi, Á., Wrbka, T. & Prinz M.A. (this issue). Landscape Character and landscape history as prerequisites for targeted crossborder nature conservation on the Green Belt of Europe – the case of Fertö / Neusiedlersee.

Krachler, R. (1992). Beiträge zum Chemismus and Wasserhaushalt der Lacken des burgenländischen Seewinkels. University of Vienna.

Krejčí, J., & Cajthaml, J. (2007). Mullerovy mapy českých zemí, jejich digitalizace a zpracování pro internetovou vizualizaci. *Kartografické listy, 15*, 9.

Kretschmer, I., & Riedl, A. (2008). Austrian (Habsburg) official cartographic activities from the First Military Survey to World War I. *Geophysical Research Abstracts, 10*, 1-2.

Křováková, K., & Brůna, V. (2007). Historical landscape of Šumava in the light of paleobotanic and antique maps' evidence. In: B.e. al. (Ed.), *25 years of landscape ecology: Scientific principles in practice. Proceedings of the 7th IALE World Congress 8 - 13 July.* (p. 881): IALE Publication Series, .

Löffler, H. (1982). *Der Seewinkel - Die fast verlorene Landschaft.* St. Pölten: Niederösterreichisches Pressehaus.

Löffler, H. (2000). The designations of bodies of water in the "Seewinkel" (Burgenland Austria) and their meaning. *Mitteilungen Der Österreichischen Geographischen Gesellschaft, 142*, 315-328.

MacArthur, R.H., & Wilson, E.O. (1967). *The Theory of Island Biogeography.* Princeton, N.J.: Princeton University Press.

Metz, H., & Forro, L. (1991). The chemistry and crustacean zooplankton of the Seewinkel pans - a review of recent conditions. *Hydrobiologia, 210*, 25-38.

Mottet, A., Ladet, S., Coque, N., & Gibon, A. (2006). Agricultural land-use change and its drivers in mountain landscapes: A case study in the Pyrenees. *Agriculture Ecosystems & Environment, 114*, 296-310.

Nationalpark Neusiedlersee-Seewinkel. (2008). Offizielle Homepage des Nationalparks Neusiedlersee-Seewinkel. *http://www.nationalpark-neusiedlersee-seewinkel.at.*

Naveh, Z. (1995). Interactions of landscapes and cultures. *Landscape and Urban Planning, 32*, 43-54.

Nestroy, O. (2005). Introduction to Austria – a general geographic survey. In: A. Aichberg, & A. Dadora (Eds.), *Soil organic matter and element interactions*: Austrian-Polish Workshop. ALVA-Mitteilungen

Nicholas, M. (2008). Distance Matrix v.2.1. *http://arcscripts.esri.com/details.asp?dbid=14567*: ESRI.

Pontius, R.G., Shusas, E., & McEachern, M. (2004). Detecting important categorical land changes while accounting for persistence. *Agriculture, Ecosystems & Environment, 101*, 251-268.

Prinz, M.A., Wrbka, T., & Reiter, K. (2010). Landscape change in the Seewinkel: Comparison among centuries. In: J. Andel, I. Bicik, P. Dostal, Z. Lipsky, & S.G. Shahneshin (Eds.), *Landscape Modelling. Geographical Space, Transformation and Future Scenarios* (p. 236): Springer.

RAMSAR. (2009). The Annotated Ramsar List: Austria. The Ramsar´Convention on Wetlands.

Reitinger, J., & Schmalfuss, R. (1992). The water regime and problems of water resource policy in the Seewinkel area on lake Neusiedl. *Oesterreichische Wasserwirtschaft, 44*, 69-76.

Reitinger, J., & Schmalfuss, R. (1993). Ergebnisse des Forschungsprojektes "Wasserhaushaltsstudie Neusiedlersee". *Archiv für Lagerstättenforschung der Geologischen Bundesanstalt, 14.*

Robinson, R.A., & Sutherland, W.J. (2002). Post-war changes in arable farming and biodiversity in Great Britain. *Journal of Applied Ecology, 39*, 157-176.

Stojanovic, A., Kogelnig, D., Mitteregger, B., Mader, D., Jirsa, F., Krachler, R., & Krachler, R. (2009). Major and trace element geochemistry of superficial sediments and suspended particulate matter of shallow saline lakes in Eastern Austria. *Chemie der Erde - Geochemistry, 69*, 223-234.

Timár, G., & Pišút, P. (2008). Changes of the sinuosity of the Morava River (western Slovakia) and their neotectonic origin. Geophysical Research Abstracts, 10, 1-1.

Timár, G., Molnár, G., Székely, B., Biszak, S., & Jankó, A. (2007). Projection and datum parameters of the second military survey of the Habsburg Empire (1806-1869) for GIS data integration purposes. *Geophysical Research Abstracts, 9*, 1-3.

Timmermann, T., Margoczi, K., Takacs, G., & Vegelin, K. (2006). Restoration of peat-forming vegetation by rewetting species-poor fen grasslands. *Applied Vegetation Science, 9*, 241-250.

Wolfram, G., Donabaum, K., Schagerl, M., & Kowarc, V.A. (1999). The zoobenthic community of shallow salt pans in Austria - preliminary results on phenology and the impact of salinity on benthic invertebrates. *Hydrobiologia, 408*, 193-202.

WRB. (2006). World reference base for soil resource. In: FAO (Ed.), *World Soil Resources Reports 103.* Rome.

ZAMG. (2002). Klimadaten von Österreich 1971 - 2000. Zentralanstalt für Meteorologie und Geodynamik.

Zimmermann-Timm, H., & Herzig, A. (2006). Ciliates and flagellates in shallow saline pans within the area of the Nationalpark Neusiedler See/Seewinkel, Austria. In: J. Jones (Ed.), *International Association of Theoretical and Applied Limnology, Vol 29, Pt 4, Proceedings* (pp. 1940-1946). Stuttgart: E Schweizerbart'sche Verlagsbuchhandlung.

Zimova, R., Pestal, J., & Veverka, B. (2006). Historical Military Mapping of Czech Lands - Positional Accuracy of Old Maps. *GIM International, 20*, 21-23.

Zulka, K.P., & Milasowszky, N. (1998). Conservation problems in the Neusiedler See–Seewinkel National Park, Austria: an arachnological perspective. In: P.A. Selden (Ed.), *Proceedings of the 17th European Colloquium of Arachnology*. Edinburgh.

Zulka, K.P., Milasowszky, N., & Lethmayer, C. (1997). Spider biodiversity potential of an ungrazed and a grazed inland salt meadow in the National Park 'Neusiedler See-Seewinkel' (Austria): Implications for management (Arachnida: Araneae). *Biodiversity and Conservation, 6*, 75-88.

Annex

Year	size (ha)	% of FA	n.	MA	QA 1st | 3rd	MD	QD 1st | 3rd
1785	1612.2	-	50	14.1	4.4 | 34.2	5.2	3.0 | 7.6
1845	1630.9	101.1	61	12.4	3.3 | 32.1	5.0	2.8 | 8.2
1856	2179.9	133.7	85	10.1	3.1 | 34.5	5.0	2.9 | 7.3
1957	951.0	43.6	65	5.8	1.6 | 14.9	4.4	2.8 | 6.7
2004	609.9	64.0	70	1.6	0.7 | 5.3	4.6	2.8 | 6.9

Table 1: Development of SLs (TP = time point, FA = Former area, n. = number of SL, MA = median area in ha, QA = 1st and 3rd quartiles of area in ha, MD = Median of distance between SLs in km, QD = 1st and 3rd quartiles of distance in km)

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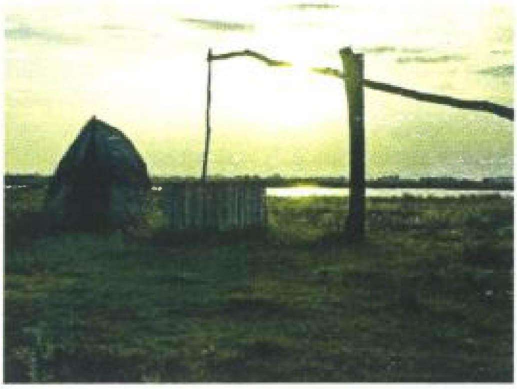


Project name: TransEcoNet

"Transnational ecological networks"

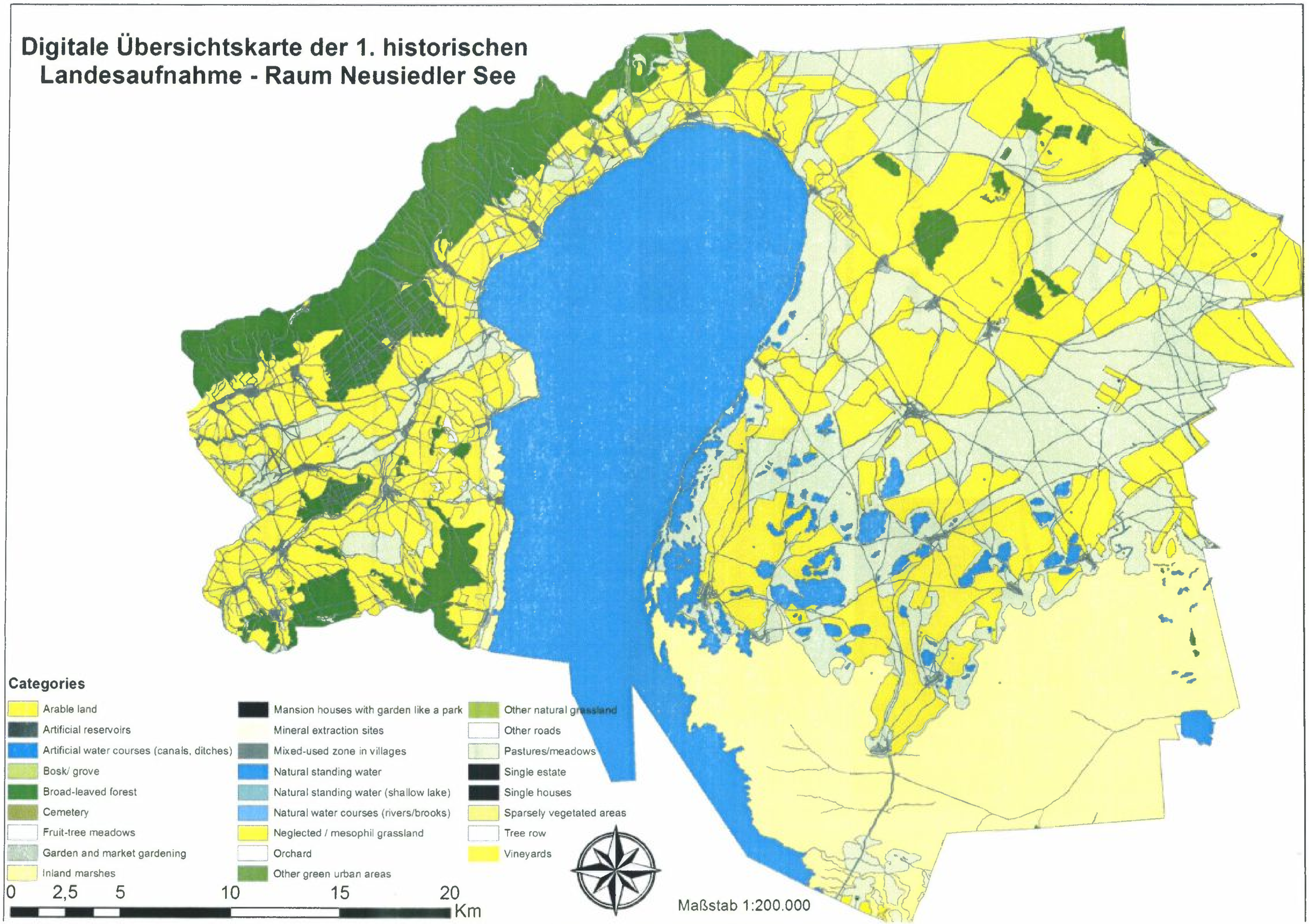
EUROPEAN UNION
EUROPEAN REGIONAL DEVELOPMENT FUND

CENTRAL EUROPE
COOPERATING FOR SUCCESS.

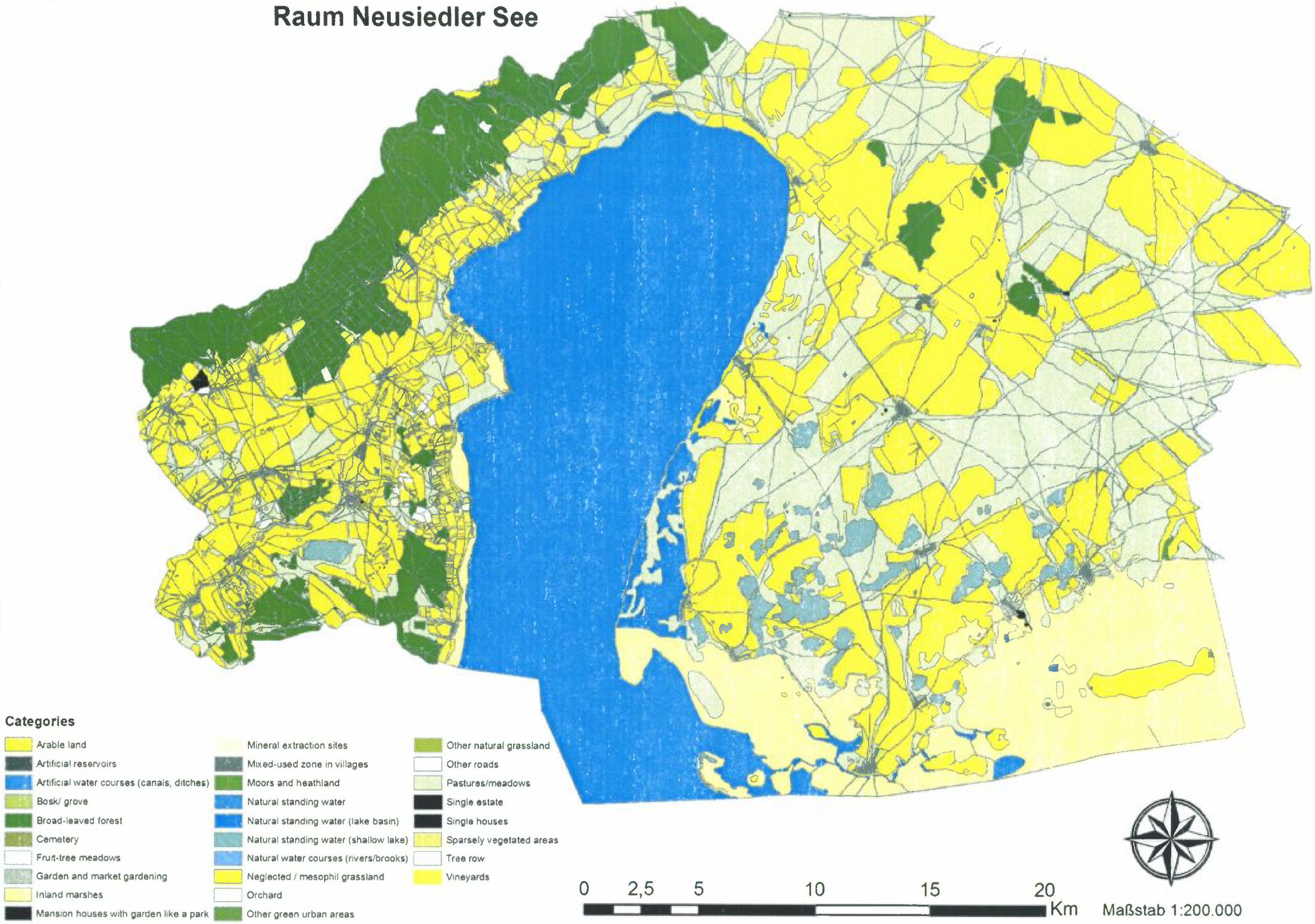
"Historical Maps"

THE HISTORY MAPS - IN THE PROJECT REGION CENTRAL SOUTH

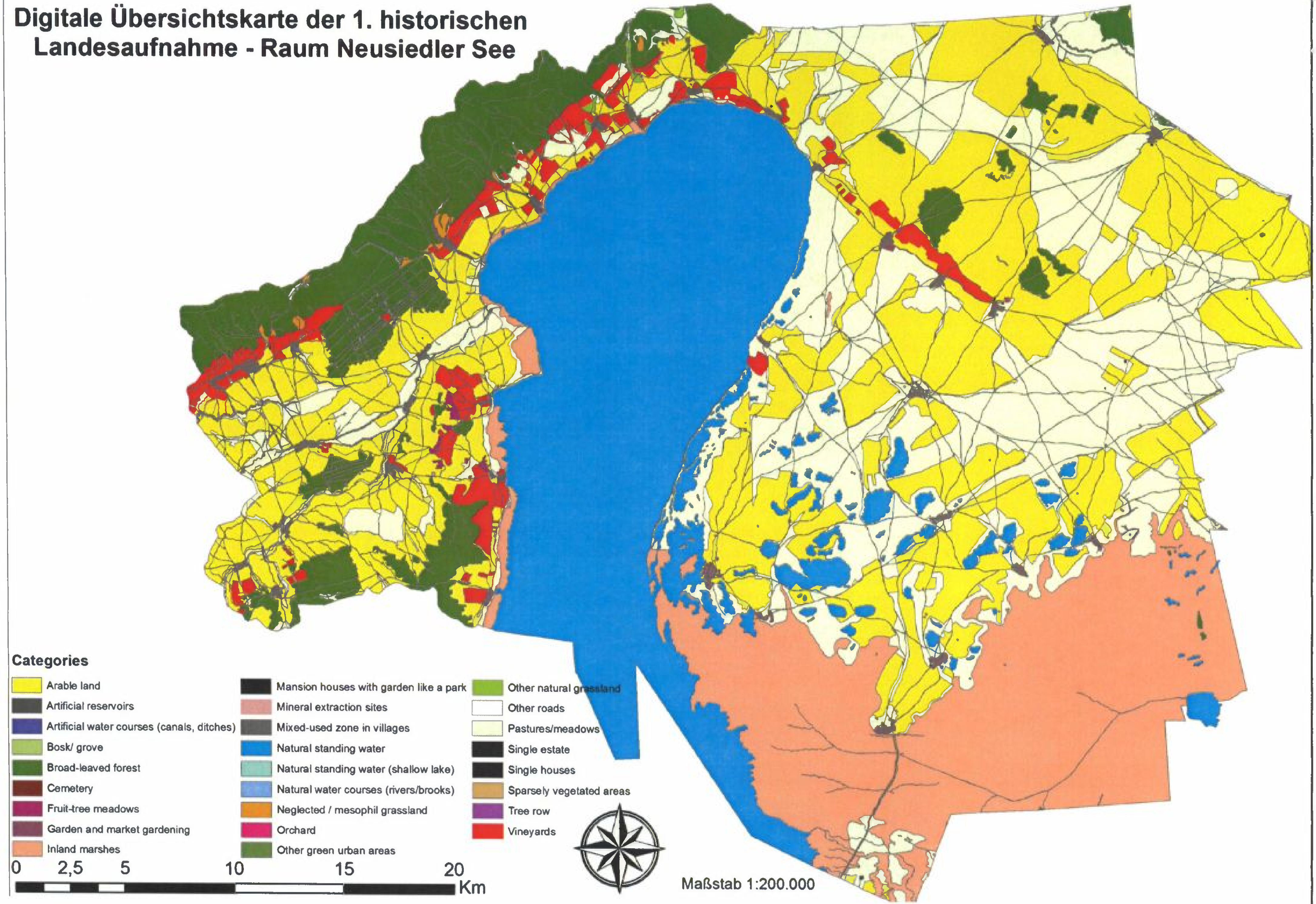
Digitale Übersicht der 1. und 2. Historischen Landaufnahme (1785 und 1845) - im Raum Neusiedler See


Digitale Übersichtskarte der 1. historischen Landesaufnahme - Raum Neusiedler See
Categories
Arable land
Artificial reservoirs
Artificial water courses (canals, ditches)
Bosk/ grove
Broad-leaved forest
Cemetery
Fruit-tree meadows
Garden and market gardening
Inland marshes
Mansion houses with garden like a park
Mineral extraction sites
Mixed-used zone in villages
Natural standing water
Natural standing water (shallow lake)
Natural water courses (rivers/brooks)
Neglected / mesophil grassland
Orchard
Other green urban areas
Other natural grassland
Other roads
Pastures/meadows
Single estate
Single houses
Sparsely vegetated areas
Tree row
Vineyards
0 2,5 5 10 15 20
Km
Maßstab 1:200.000

Digitale Übersichtskarte der 2. historischen Landesaufnahme - Raum Neusiedler See



Digitale Übersichtskarte der 1. historischen Landesaufnahme - Raum Neusiedler See



Digitale Übersichtskarte der 2. historischen Landesaufnahme - Raum Neusiedler See