Airborne Optical Imaging in Support of Habitat Ecological Monitoring of the Austrian Reed Belt of Lake Neusiedl

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1 Introduction

The reed belt of Lake Neusiedl is one of the most important habitats of the National Park Neusiedler See - Seewinkel. The Austrian and Hungarian parts of the reed belt extend over approximately 181 km² and represent the second largest contiguous reed population in Europe. These vast reed areas provide a unique ecotope which is a multifunctional core area of the National Park region. However, there are relevant conflicts between the interests of tourism and reed harvesting on the one hand and the objectives of nature conservation and ecological management on the other. A habitat ecological approach to an inventory of the reed belt is urgently needed and should be performed in regular intervals. In the frame of the research project „Schilfkartierung Neusiedler See" airborne optical scanner data of the Austrian part of the reed belt was acquired beginning of August 2008. In order to fully preserve the specific structural varieties of reed areas which are of initial importance for a habitat ecological inventory object-based image analysis was adopted via adaptive segmentation and subsequent classification. A detailed data base mirroring habitat ecological characteristics of more than 100km^2 of reeds allows for subsequent sub-regional monitoring of relations between species-related population dynamics and habitat structures. Operationality of homogeneous data collection and data analysis points towards the establishment of crossborder periodical monitoring based on airborne optical imaging as a precondition for fulfilling respective national and international directives.

2 Motivation

Lake Neusiedl is characterised by a very shallow lake basin, which allows optimum conditions for reed growth. Reed (*Phragmites australis*) extends over approximately 181 km^2 and thus represents the second largest contiguous reed area in Europe. The reed belt is a unique diversely structured ecotope. Conflicts between ecological and economical interests drive permanent discussion about strengths and weaknesses of regional development measures which often directly interfere with measures of protection and conservation. Therefore a detailed updated spatial data base on distribution, extent and structure of the reeds of the Austrian part of Lake Neusiedl was urgently needed. The habitat ecological spatial inventory is a precondition for establishing a fully-operational reed information system for the whole lake basin in support of planning and management for nature conservation.

3 Data and methods

Airborne colour-infrared (CIR) imagery was acquired on 8 August 2008. After ortho-rectification 132 .tiff images with respect to the geodetic datum MGI were available, each covering an area of 2,5 km x 2 km and consisting of 10 000 x 8 000 pixels, thus providing a ground resolution of 25cm.

2.1 Segmentation

After preprocessing, explicitly radiometric correction and similar, segmentation was performed to preserve the specific habitat ecological structures of the reed belt. Input was image data of three spectral bands (near infrared, red and green) as well as the Normalised Difference Vegetation Index (NDVI). In average around 3 000 to 4 000 segments were created per image in order to preserve a maximum of richness of detail. Anyhow expert-based editing proved to be inevitable because selection of representative habitat structures is not related to criteria such as smallness or largeness, but depends on specific habitat functions. Often very small objects like areas of open water inside the reed belt which are exactly detected by the segmentation algorithm have to be preserved and larger objects in closed reed areas which are characterised by changes of the vegetation continua type have to be merged. After expert-based treatment around 1.000 to 1.500 segments per image were available for subsequent classification (Figure 1).

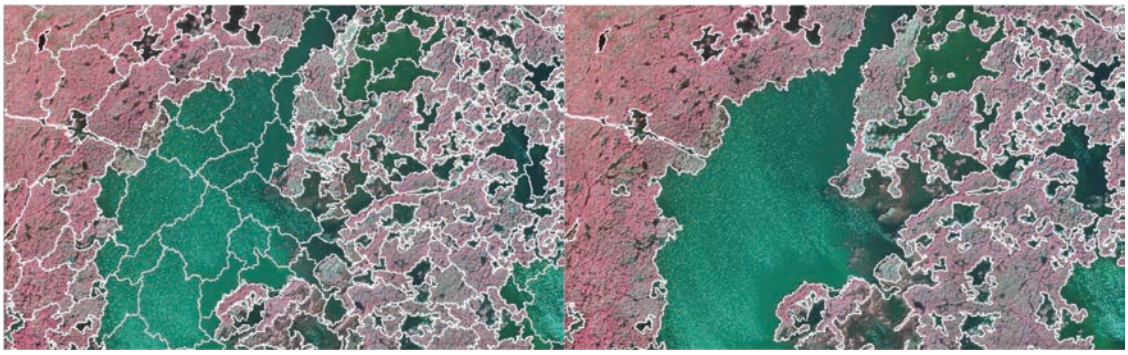

Figure 1 Reed area after segmentation (left) and after expert-driven merging (right).

2.2 Ground truthing

In September and October 2008 GPS-supported ground-truthing was performed at 45 randomly selected circle-shaped sample locations along vertical transects in 5m and 10m distance from the centre and at the centre itself. Nine measurements per sample of vegetation density and vegetation height, amount of collapsed reed, thickness of reed stems and amount of young reed (of the recent year) as well as - in case of occurence of water surface – amount of coverage and water depth were collected. Field data collection was following criteria of habitat ecological inventories regarding habitat preferences of different reed birds (Dvorak et al. 1995; Nemeth et al. 2001).

2.3 Classification

Based on in-depth ground-truthing and on-screen interpretation training a classification key was developed which mirrors the capacity of very-high-resolution CIR-image analysis to classify reeds towards habitat ecological characteristics, explicitly by application of separation criteria

of horizontal structure (density, fragmentation, heterogeneity), vitality (age distribution) and growing height (stereo-imaging). A respective interpretation key has been established at the occasion of the first full-coverage mapping of the Austrian reed belt in the early 1980s (Csaplovics 1982). The recent classification key separates between pure reed and mixed reed classes, open water, channels, fillings and tourism facilities. There are five distinctive reed classes which are differentiated by the criteria density (structure) and age (vitality) of reed cover, patchiness (open water) as well as the distribution of other plants. The mixed reed classes consider the distribution of sedges (mostly *Cladium mariscus*) as well as mixed marshland in general (Márkus et al. 2009). Anyhow, as the „Hungarian classification key“ was solely developed based on occurrence of respective reed classes in the Hungarian reed belt, the „Austrian classification key“ had to be amended and extended in order to take into account the distinctive variations of reed growth (Schmidt et Csaplovics 2012).

3 Results

In the northwestern part of the reeds near the Wulka inflow a large homogenous area of old reed is prevalent. Further to the south the density of reed decreases and an increasing amount of water (“Braunwasser”) is characteristic. It is obvious that areas dominated by sparse old reed prevail in the Austrian part of the reed belt (Figure 2). Reed classes III.A, IV.A and V.A extend over approximately 69 km², while vital, young, dense reed covers only about 20 km². Mixed vegetation of reed and sedges (classes I.B through V.B), partly dispersed over marshland, represents about 16 km². A significant amount of the inner parts of the reed belt, explicitly 12.5 km^2, is covered by open water (reed water, *Braunwasser*). Along the open-water reed edge vital, dense, young reed prevails. The landward transition zone is dominated by a mixture of young, vital reed and marshland as well as abundance of sedges, often distributed along vegetation continua gradients.

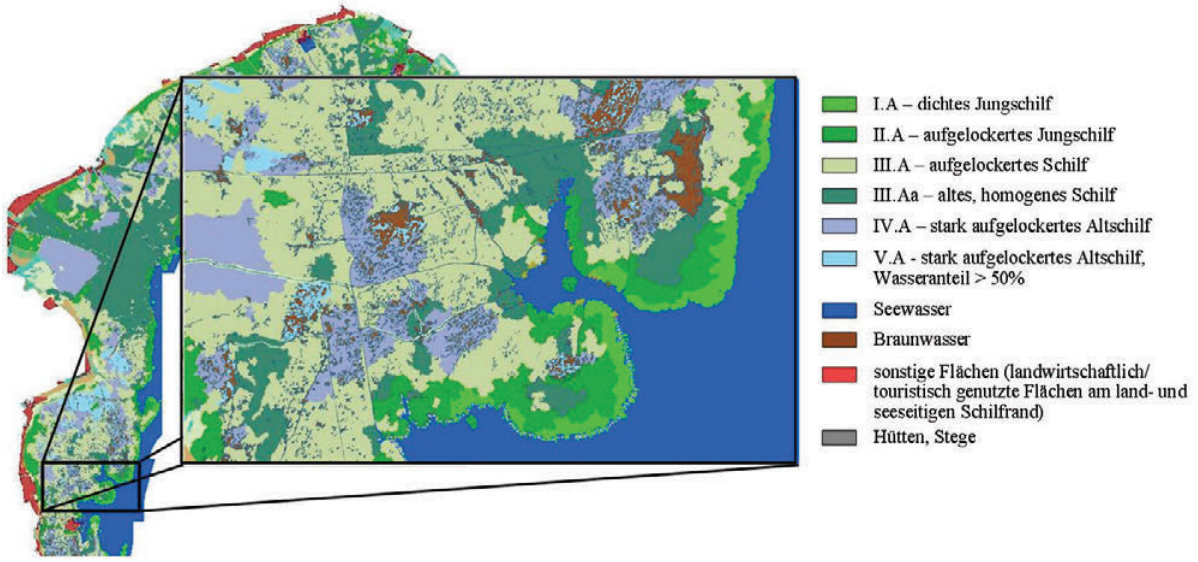

Figure 2 Habitat-ecological map of the reed belt of the Austrian part of Lake Neusiedl (detail) (Csaplovics et Schmidt 2011).

Habitat-ecological interpretation of reed classes relies on the fact that preferences in habitat choice of reed birds are significantly correlated with adequate reed structure as well as with variations in water level inside the reed belt. The reed belt hosts bird populations of international significance. In total 35 species are found along the edge and inside the reed belt which are

listed as species of priority following the European Birds Directive (Species of European Conservation Concern SPEC, categories 1-3). Habitat selection of wading birds (herons and similar), but especially of small birds is to a large extent determined by structural parameters of the reed areas. While the Moustached Warbler *(Acrocephalus melanopogon)* and Little Crake *(Porzana parva)* prefer open reed areas with a large amount of collapsed reed, the Great Reed Warbler (*Acrocephalus arundinaceus*) is found in areas characterised by significantly dense and strong reed stems. Habitat-specific parameters of reed structure and amount of open water areas inside the reed belt are perfectly assignable to classes derived from colour infrared aerial image analysis. Prediction of the occurrence of bird species in relation to specific parameters of reed structure and patchiness in core areas of the national park is possible. The Water Rail (*Rallus aquaticus*) colonises along the reed edge both landwards as well as towards the open water in areas with predominantly thick reed stems (Figure 3).

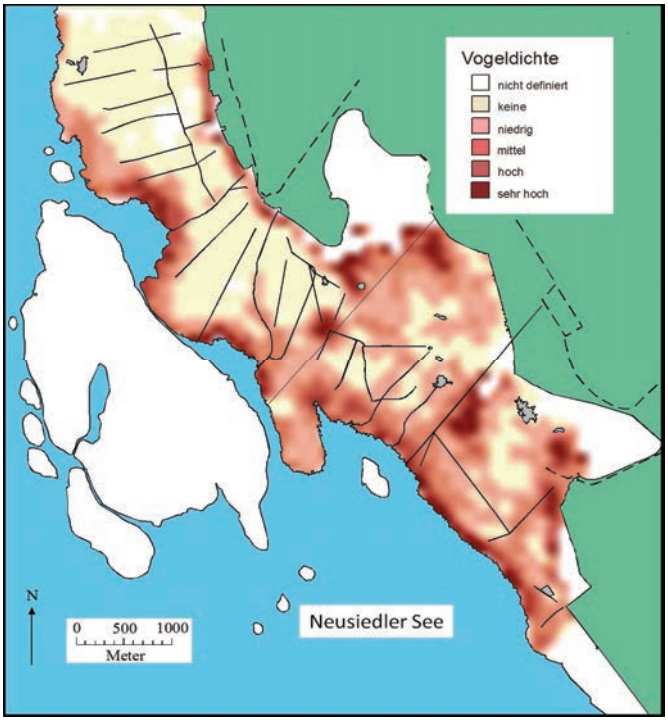

Figure 3 Distribution of the occurrence of Water Rail (*Rallus aquaticus*) in the core area of the National Park Lake Neusiedl based on reed of significant vitality and low density of open water patches (Nemeth et al. 2001).

4 Conclusion

The Austrian-Hungarian reed belt of Lake Neusiedl/Fertö covers an area of approximately 181 km^2 including the reed-land transition zone (effective 2008), with the Hungarian part of about 64 km^2 and the Austrian part of about 117 km^2, thus representing the second largest contiguous reed area in Europe (surpassed only by the reeds of the Danube Delta). It is remarkable that reed areas with densities of reed growth lower than 70% cover an extraordinary large area of approximately 35% of the Austrian reed belt and that more or less distinct open water areas inside the reeds cover about 15% of the Austrian reed belt. A comparison with the distribution and extent of open water areas described by the „historical“ inventory of 1979 proves for a tremendous increase from 2.5km^2 to 12.5km^2 (Csaplovics 2012). Comparative analysis of changes in reed extent and reed structures in relation to the prediction of population densities of reed birds and other rare faunistic species creates a sound baseline for crossborder ecological

monitoring and management of reed habitats of Lake Neusiedl in concordance with European regulations and directives.

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