PLANT INVASIONS RECORDED BY REMOTELY SENSED DATA, COMPARISON OF DIFFERENT DATA SOURCES

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KEYWORDS: Aerial Photographs, Vegetation, Invasion, Change detection, Comparison of Data Sources, Historical Analyses, Rapid Eye

Invasive species currently represent a major conservation issue. Precise information on the spatial structure of invasion and techniques enabling its fast and precise monitoring is needed to implement efficient management strategies. Historical aerial data provide us with a unique possibility to study the changing landscapes, and at fitting circumstances (appropriate time of acquisition, good recognizability of target, long time series), can be used for a detailed study of invasion processes. Historical data are usually panchromatic with limited spectral information, quality, and coverage (usually scattered). On the contrary recent satellite multispectral data provide good quality spectral information on landscape features and vegetation and are available repeatedly over large areas. Analyses of historical landscape changes using aerial and satellite data create a challenge of combining the data of different spectral and spatial resolution.

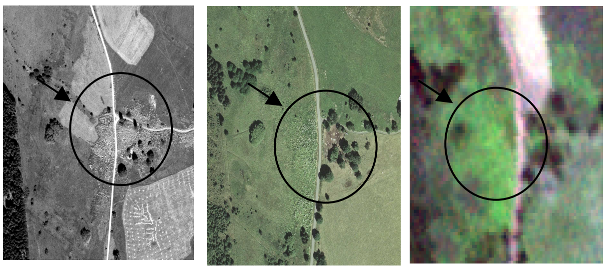
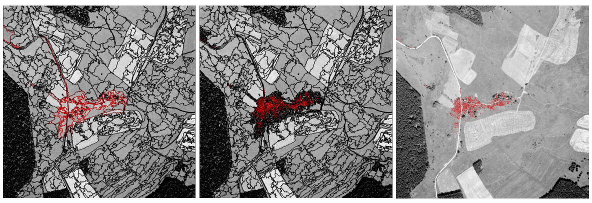


Figure 1. Giant hogweed on panchromatic (1962, Military Topographic Institute, Dobruška), color aerial photography (2006, GEODIS, Prague), and multispectral satellite imagery (2010, Rapid Eye AG).

We used a comprehensive set of aerial photographs (1947 to 2006, panchromatic, multispectral and color) and satellite imagery of 2010 (Rapid Eye). Such a large data set provided us with a unique opportunity to trace from the very beginning the invasion of a noxious invasive plant species, giant hogweed (*Heracleum mantegazzianum*), the largest central European forb up to 4–5 meters tall, with white flower heads up to one meter in diameter. Inflorescence size, as well as its distinct shape and color enable recognition of individual plants on panchromatic photographs; on satellite data of spatial resolution lower than the size of individuals, such as Rapid Eye, only larger homogeneous stands can be recognized (Figure 1). In previous papers we described fifty years of invasion in the Slavkovský les, Czech Republic, studied by manual analyses (on-screen digitization; Müllerová et al., 2005) of historical aerial imagery. Invasion progress was related to changing landscape parameters to study the dispersal of this species (Nehrbass et al., 2007; Pergl et al., 2011), and compare the rate of invasion at different scales (Pyšek et al., 2007; Pyšek et al., 2008). In this study, we assessed the detection of hogweed from spectrally (panchromatic and multispectral) and spatially different remote sensing data, and established relatively fast and efficient computer-assisted methods of invasion monitoring (time-effective and standardized) that could be applied over large areas.



Course segmentation Fine segmentation Classification results

Figure 2. Object-based image analyses in Definiens. Giant hogweed region in segmentation process and resulting hogweed class in classification results are marked in red.

Aerial and satellite imagery were analyzed by both object- and pixel-oriented approaches. Unsupervised (ISODATA, K-Means and Fuzzy K-Means), and supervised (Maximum Likelihood and Minimum Distance) pixel-based classification approaches (Jensen, 2004) were tested using Geomatica (Geomatics Enterprises Inc.). Training areas for supervised classification were selected from visual interpretation (historical data) or field data (2010). For object-based image analyses (OBIA), hierarchical, iterative semi-automated approach was applied using Definiens Developer 8 software (Definiens AG, 2009). The segmentation parameters (scale, color, shape) were determined using a systematic trial/error approach. Various scales were tested and segmentation outputs were visually evaluated to identify the best parameters to extract the targets of interest. Segmentation was performed on two hierarchical levels. Rule-based classification was then applied on the segmented objects using rules related to spectrum, shape, texture, and context (Figure 2). The accuracy assessment of hogweed classification was based on visual interpretation of the data and/or field data in case of recent imagery.

Results of tested classification approaches differed according to the type of imagery. Comparing pixel and object-based approaches, poor spectral resolution of panchromatic and color imagery did not provide sufficient base for pixel-based approach. Additional information on shape, texture and context of mapped objects (hogweed individuals) incorporated in OBIA enhanced classification success considerably. As for the satellite imagery, its spatial resolution allowed only identification of larger hogweed stands hence the spectral information was crucial. Pixel-based methods (supervised classification) were therefore more successful for satellite data analysis, with Maximum Likelihood providing the best results. Unsupervised classification did not provide satisfactory results for any type of data. Right timing of the data acquisition was another important element in remote sensing detection of the species. Our study established comparably fast detection method of hogweed, a noxious invasive species. We consider our methodology broadly applicable, enabling an early detection of this species that would make management measures more efficient and less expensive. Knowledge on mechanisms of this species spread, its habitat preferences, and on the driving forces in landscape will help us to understand why certain habitats are more susceptible to invasions than others.

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