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The Impact of Alien Plant Species on the Conservation Success of a Protected Natura 2000 Area within the Ecological Restoration of the River Traisen, Lower Austria

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Abstract

The invasion of alien plant species into protected areas has a serious negative impact on the abundance and diversity of the native flora as well as on natural ecosystem processes. For protected areas in particular, the ongoing distribution of invasive species has become a major issue. The objective of this study was to examine the development of invasive species in a riparian ecosystem, namely the planned floodplain restoration area at the mouth of the river Traisen in Lower Austria. The territory for the study lies within a Natura 2000 area, where the regulated riverbed will be revitalized as part of the LIFE+ project "Traisen". Nine invasive plant species were recorded. During the last two years of study the distribution of the species *Bunias orientalis, Impatiens parviflora, Impatiens glandulifera,* and *Solidago gigantea* increased massively. The development was evaluated using a grid of 142 recording sites. In the riparian forests in particular, the proportion of invasive species to native species in the overall species composition increased during the recording period. The Shannon diversity index showed different developments for specific riparian plant communities. Furthermore, the seed bank and phenology were analysed in order to create a monitoring concept for the planned ecological restoration of the floodplain. The goal of this monitoring is to reduce the occurrence of invasive species in protected riparian areas focused on the protection of endangered native species.

Keywords

invasive alien species, riparian, restoration, biological invasion;

Introduction

Riparian areas are important habitats for various ecological functions and European plant diversity (GREGORY *et al.* 1991, NAIMAN & DECAMPS 1997, PFADENHAUER 1997, HOOD & NAIMAN 2000). In the past decades, European riparian zones have been strongly affected by biological invasion (PYŠEK et al. 1994, ESSL et al. 2002, SCHMITZ & LÖSCH 2005). The increasing number of scientific studies in this area emphasizes the importance of the ongoing ecological changes and consequences of biological invasions (LOHMEYER & SUKOPP 1992, RICHARDSON & PYŠEK 2006). The issue of invasive alien species is regularly discussed in several international conventions and nature conservancy programs (CLOUT & WILLIAMS 2009).

The entire area was regulated in the 19th century in order to reduce the number of floodings and increase the available land area for cultivation. During the construction of the Danube power plant Altenwörth in the 1970s, the outfall of the river Traisen was relocated. Although the relocation had a negative influence on the ecological situation, the species richness of the project area was calculated to be very high. The occurrence of species of the fauna-flora-habitat directives is similarly high. Therefore the area was incorporated into the EU-wide network of Natura 2000 sites, a network of nature protection areas established under the Habitats Directive and Birds Directive (1979). Since 2004, the area has been part of the Natura 2000 FFH site 16 "*Tullnerfelder Donau-Auen*" (www.noe.gv.at). The site covers a total area of 19,483 ha (ELLMAUER et al. 1999). One of main foci of this Natura 2000 site is the protection and support of riparian vegetation. The ecological function of riparian forests, broadleaved alder forests, transitory phytocoenoses and dry grasslands of the riparian areas in particular are among the important protected and supported entities in the "*Tullnerfelder Donau-Auen*" (www.noe.gv.at/natura2000). The aim of the Habitats Directive (1992) is to assure the long-term survival of Europe's most valuable and threatened species and habitats (ec.europe.eu). Human activities are not excluded from the management of Natura 2000 sites, as long as the management is ecologically and economically sustainable (SHARPSTON 2010). The Natura 2000 site "*Tullnerfelder Donau-Auen*" constitutes one of the largest connected riparian ecosystems in Austria. But the ecological structure and function of the riparian area are strongly endangered due to the construction of the Danube power plants Altenwörth and Greifenstein. The installation of these power plants caused noticeable changes in the Danube's hydrology. Most of its abandoned meanders were disconnected from the main stream; but without these important cross-links to the main stream, the ecosystem is highly endangered. Furthermore, the reduction of river flooding leads to massive disturbances within gallery forests (www.noe.gv.at/natura2000). The ecological restoration of the river Traisen is now planned.

The main goal of the project Life+ Traisen is the improvement of the hydro-ecological condition of the downstream section and the outlet of the river Traisen. The planning of the project follows specifications of the European Water Framework Directive. Besides hydrological and hydrobiological objectives, one purpose of Life+ Traisen is to create natural riparian habitats with characteristic vegetation structures. In keeping with the objective of the restoration project, the main focus of experiments and analysis for this study was placed on invasive species within the herb layer.

In summary, the objectives of this study is a contribution to the analysis of the development of biological invasion of alien plant species on the one hand; and on the other hand, the discussion of challenges, interdependence and perspectives of restoration programs within the conservation targets of a Natura 2000 site in general.

Methods

The studied alien species were selected according to the time of their introduction and establishment. Non-native species introduced to Europe after 1492 are classified as alien species (SUKOPP 1969, ADLER & FISCHER 1994).The vegetation sampling includes all occurring vascular plant species. To assess the quality of plant diversity as well as vegetation coverage and development, a grid of coordinates was placed over the research area. Within these random localized coordinates, a grid of 142 recording areas (10m X 20m) was selected. The parameters habitat characteristics, occurrence and number of species, and abundance and dominance (BRAUN-BLANQUET 1964) were recorded for each site in the years 2011, 2012 and 2013..The seed bank analysis was performed on 89 random sites (October 2011). Within each of these sites, 3 plots were randomly taken using a soil cutter with a diameter of 2.6 cm and a depth of 20cm. The plots were collected separately for the soil layers 0-5cm, 5-10cm and 10-20cm. A germination test was then done using the rising method. The detected seeds of each sample were put in Petri dishes filled with absorbent papers, and kept for 40 days in a greenhouse without artificial day-night-control (temperature: 20 – 25°C; humidity: 60-90%). A seed was regarded as germinated if it produced a radicula (BERNHARDT et al. 2008).For a representative observation of the phenological characteristics of invasive plant species in the riparian area, 8 sites were selected. A vegetative and a generative scale were used to detect phenological development (DIERSCHKE 1994). Statistical computing and graphics "R" (32-bit) were applied (R Core Team, 2012), and the Shannon diversity index was chosen to calculate the influence of the occurrence and development of invasive alien plants on the native diversity (MAGURRAN 1988, PINHEIRO et al. 2010).

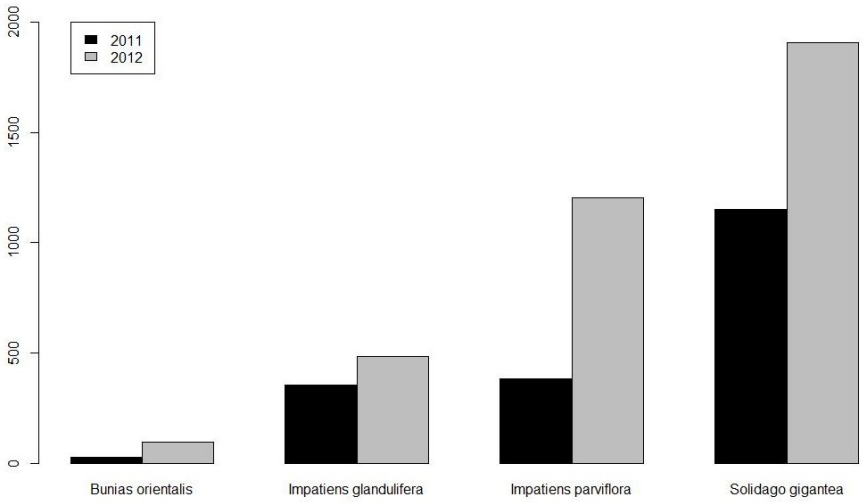

Figure 1: comparison of the total number of detected seeds and the total number of germinated seeds of *Impatiens glandulifera*, *Impatiens parviflora*, *Solidago gigantea* and *Bunias orientalis* for all samples of all layers.

Results

The vegetation sampling of 142 recording surfaces documented the occurrence of 9 invasive alien plant species. *Acer negundo, Ailanthus altissima, Bunias orientalis, Fallopia japonica, Robinia pseudoacacia, Rudbeckia laciniata, Impatiens glandulifera, Impatiens parviflora, Solidago gigantea* were recorded within four different vegetation layers and regarded as invasive alien plant species (ESSL et al. 2002). The comparison of the results of 2011 and 2012 show a significant increase of invasive alien plants (Fig. 1). 23 species included in the IUCN Red List were also recorded (KURMANN & BERHARDT 2013). A total number of 89 plots were analysed using combined sampling of the aboveground vegetation coverage and the underground density of seeds of invasive alien plants. In total, 163 seeds of the species *Impatiens glandulifera*, 83 seeds of *Impatiens parviflora*, 438 seeds of *Solidago gigantea* and 34 seeds of *Bunias orientalis* were detected. The majority of invasive plant seeds (n=499) were detected in the samples from the upper layer (0-5cm). The results of the germination test showed that of the 717 total seeds found, 396 (55%) germinated. The percentage of germinated seeds decreased with the depth at which they were found. The highest germination rate was that of the species *Solidago gigantea*,with a total of 68% of seedsgerminated. Analysis of the germination results showed that 80% of all germinable seeds germinated within the first 10 days.

Invasive alien plant species *Bunias orientalis, Impatiens glandulifera, Impatiens parviflora* and *Solidago gigantea* comprised an average of 71% (2011) and 84% (2012) (n=89 sites) of the total coverage of the herb layer.

An average of 1.8 seeds of *Bunias orientalis*,0.9 seeds of *Impatiens glandulifera*,4.9 seeds of *Impatiens parviflora* and 0.4 seeds of *Solidago gigantea* were detected. *Solidago gigantea* was the most abundant invasive species. Overall species richness (Shannon index) decreased as the occurrence of seeds of invasive alien species in the seed bank increased. The species diversity of each plot showed a significant negative relationship with seed density of *Impatiens glandulifera* ($p=0.03$, $r^2=0.05262$) (Fig.2). The occurrence of seeds of *Solidago gigantea* show a positive (though not significant) relationship to the total aboveground cover of the herb layer($p=0.6537$, $r^2=0.00232$). While the results represent the presence of seeds of invasive species in the seed bank, the spreading of invasive alien plants sampled aboveground into previously not invaded areas is not related to the occurrence of their seeds in the seed bank.

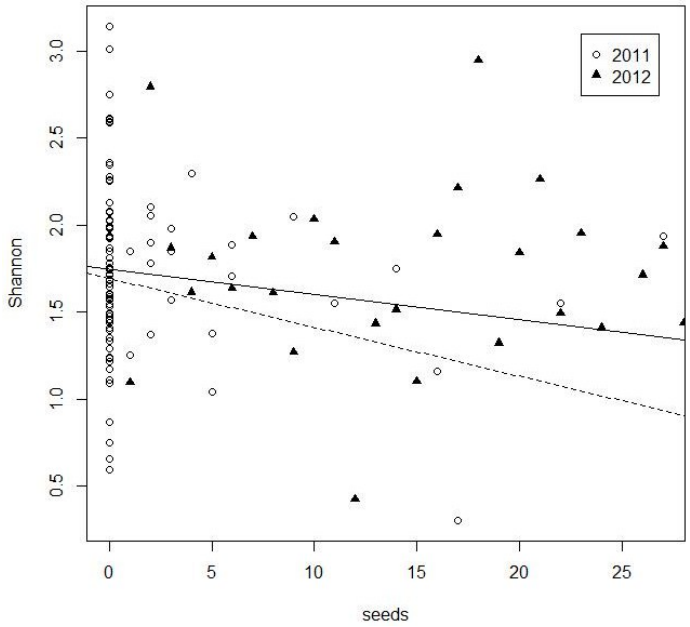

Figure 2: Regression analysis of the relationship between mean seed density of *Impatines glandulifera* and mean Shannon diversity index of aboveground plant species composition in the study year 2011 and 2012.

Discussion

The high level of species richness and diversity of habitats in the study area can primarily be seen as the remains of the natural riparian ecosystem that was destroyed by various human interventions (ELLMAUER et al. 1999). Immediately following the regulation of the river Danube and the artificial relocation of the river Traisen, species richness decreased noticeably. The restoration of the river Traisen within the project Life+ Traisen aims to construct new typical riverine habitats and improve the ecological conditions of the study area's diversity (EBERSTALLER et al. 2000).

The new re-naturalised downstream section of the river Traisen is not merely an opportunity to improve the ecological situation, but also a challenge to reap the benefits of diversity without supporting the ongoing invasion by alien plant species. The characteristic vegetation structure of natural riparian habitats includes, among others, forests with populations of *Salix alba, Salix purpurea* and *Salix virminalis* (PFADENHAUER 1997). The construction of the new riverbed profile of the river Traisen primarily supports the FFH habitat types of softwood forests. The result of seed bank analysis and vegetation development sampling show that areas with high human disturbance are greatly affected. In order to achieve the restoration´s goals of improving diversity in the area, a concrete concept for invasive species management needs to be developed. The vegetation sampling showed a high percentage of invasive plant species in the herb layer in sites with naturally low species richness and sites with low total cover. However, the planned restoration will create large areas of such uncovered and open ground. The restoration plans therefore need to be considered carefully in order to achieve their goals (SUDING et al. 2004, RICHARDSON et al. 2007). The objective of the monitoring is to observe the construction processes from their earliest stages and implement measures as soon as possible. One possible method of reducing the expected spreading of *Impatiens glandulifera* in the constitution area, which will be tested in 2013, is to support the desired growth of *Salix alba, Salix purpurea* and *Salix virminalis.*

The plant diversity of the Natura 2000 site "*Tullnerfelder Donau-Auen*" in the study area is highly endangered due to the construction of two Danube power plants and the regulation of the river Danube. A significant number of species on the IUCN Red List (SCHRATT 1990)(NIKLFELD & SCHRATT-EHRENDORFER 1999) were recorded during the vegetation sampling drives of 2011 and 2012 (KURMANN & BERNHARDT 2013) , and the documented diversity is still high. However, the increase in the total number of invasive plant species is endangering the general objectives and specific targets of protection. This biological invasion must be discussed and reflected in terms of the management and land-use programs of the area.

The (in some areas massive) dominance of invasive species renders removal of these invaders economically unaffordable and in most cases also ineffective, and therefore undesirable (DEL TREDICI 2004). With respect to

ecosystem services, the removal of alien plants from massively invaded river embankments is potentially counter-productive (RICHARDSON et al. 2007). Studies have shown that the situation of conservation management and restoration in riparian ecosystems is extraordinary complex (HAGER et al. 2007, DIDHAM et al. 2005, CLOUT & WILLIAMS 2009). Open and dynamic hydrological structures create individual riparian vegetation compositions. A successful conservation management of invasive species and ecological restoration of riparian vegetation calls for participative solutions including human land-use concepts and natural ecosystem services. Small-scale and long-term restorations are recommended (SWEENEY et al. 2002, RICHARDSON et al. 2007). Analysis of the seed bank and the phenological development of invasive plant species help to specify monitoring measures. The goal of achieving conservation targets requires active monitoring measures to protect hitherto non-invaded areas from biological invasion in order to maintain the integrity of protected natural areas for the protection of native flora.

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