LIFE+ RIPISILVANATURA: Biomonitoring and short-term assessment of restoration measures to control invasive alien species in the Segura River (Spain).

LIFE+ RIPISILVANATURA: Suivi et évaluation à court terme de la restauration des berges pour contrôler les espèces envahissantes dans la rivière Segura (Espagne).

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RÉSUMÉ

Les espèces envahissantes sont une des cinq principales causes de la perte de biodiversité. Différentes méthodes ont été utilisées traditionnellement pour contrôler le grand roseau (*Arundo donax*) à la zone méditerranéenne. Nous avons testé l'efficacité d'une stratégie encore non-évaluée mise en place par le projet LIFE13BIO/ES/001407 RIPISILVANATURA. Cette méthode consiste en une coupe répétée combinée avec la plantation des espèces indigènes. Nous avons examiné si la végétation riveraine, les oiseaux et les macroinvertébrés aquatiques étaient affectés par ces actions de restauration. Pour cela, nous avons réalisé un suivi annuel (échantillonnages avant et pendant les mesures de restauration de 2015 à 2017) dans un ensemble de stations représentatives, et analysé l'évolution de différents indicateurs écologiques à partir de modèles à effet mixte. Pour la végétation riveraine, nous avons observé une réduction significative de la hauteur de grand roseau, une augmentation de la richesse spécifique et une amélioration de l'état écologique. De plus, nous avons observé une augmentation de l'abondance et du nombre de familles de macroinvertébrés aquatiques, mais aucun effet significatif sur les oiseaux. Bien que nous ayons observé une amélioration globale, les valeurs des indicateurs écologiques sont loin des valeurs de référence; par conséquent le traitement et le suivi écologique doit être prolongé afin d'obtenir des résultats satisfaisants.

ABSTRACT

Invasive alien species are among the top five causes of biodiversity loss. In particular, giant reed (*Arundo donax*) has colonized progressively the Mediterranean zone. Different methods have been traditionally used to control it. We assess the effectiveness of a non-evaluated strategy implemented through the project LIFE13BIO/ES/001407 RIPISILVANATURA: repeated pruning (with different temporal frequencies) combined with the plantation of native species. We also assess if related biological communities such as birds and aquatic macroinvertebrates show significant responses to restoration through annual biomonitoring (sampling before and during the restoration from 2015 to 2017) in a set of representative stations. We analyzed the change of several ecological indicators through mixed-effect models. Regarding riparian vegetation, we observed a significant reduction of the giant reed height, an increase of species richness and an improvement of the ecological status. Complementarily, aquatic macroinvertebrates increased in abundance, number of families and quality whereas birds did not respond significantly. Although some general improvement was observed, the values of the ecological indicators used are still far from reference values so both the treatment and monitoring should be extended in time to reach satisfactory results.

KEYWORDS

Aquatic macroinvertebrates, *Arundo donax*, birds, riparian vegetation, river restoration

1 INTRODUCTION

Rivers have experienced intense and long-standing human pressures which have caused the impairment of aquatic and riparian habitats. These impacts favour the spreading of opportunistic and exotic species, with a detrimental effect on native communities. In particular, the giant reed (*Arundo donax*) has colonized progressively the Mediterranean zone, being part of one the 100 most dangerous invasive species worldwide. In Spain, and especially in the Segura River basin, the giant reed is thoroughly spread disturbing the native riparian vegetation. Different methods have been traditionally used to control giant reed: burning, chemical treatment (glyphosate), plastic layering, flooding or weeding, among others (Deltoro *et al*., 2012). Most of these methods are valid for degraded areas where *Arundo donax* dominates completely but not for river reaches where this species coexists with native vegetation and/or in protected areas, where less aggressive methods are required to avoid altering plant competition and ecological succession. Previous eradication campaigns have usually been performed locally (especially in lower reaches where *Arundo donax* forms extensive monospecific clumps) and without any coordination or long-term planning resulting in high costs and poor results. River restoration projects should lie in coordinated holistic measures planned at broad scale rather than on local disconnected actions, to develop more effective management strategies. In this context, LIFE13BIO/ES/001407 RIPISILVANATURA (2014-2019) aims to control invasive alien species by strengthening riparian habitats (specially the 92A0 of European Directive 92/43/CEE) in moderately disturbed middle reaches, where both invasive species and remnants of riparian native vegetation are present. Therefore, it aims to weaken *Arundo donax* while expanding native riparian cover through coordinated soft-engineering techniques, in order to enhance the competition exerted by native species. Furthermore, these restoration measures were planned holistically by including aquatic, terrestrial and social components as a way to reach long-lasting successful results. Thus, the project incorporates a land stewardship network to involve local population, an alert system to detect and remove invasive alien species, the demarcation of riparian area to improve ecological integrity and expand riparian habitats, the removal of embankments to recover lateral connectivity, environmental awareness campaigns, personnel training, protocols and handbooks to optimise riparian management and conservation, increased fire surveillance, the protection of riparian birds by marking power lines and the creation of bird observatories.

Our objective is to make a preliminary evaluation (in the middle of the RIPISILVANATURA project) of the effectiveness of a previously non-evaluated strategy to face the invasion of *Arundo donax* in Mediterranean areas: repeated pruning with two different frequencies (monthly vs. quarterly) during two years combined with the plantation of native species. We also assess if related biological communities such as riparian birds and aquatic macroinvertebrates show significant responses to these restoration actions. We expect a reduction in invasive species cover and an improvement of the ecological status of the target riparian habitats and associated communities.

2 METHODS

Located in one of the driest zones of Europe (SE Spain), the Segura River is an environmentally diverse basin due to anthropogenic and natural gradients under a predominantly semi-arid climate. Despite the remarkable presence of forested or semi-natural areas (45.2%), the expansion of agricultural land (52.1%) and increased flow regulation have caused a progressive reduction of natural areas and the spread of invasive alien species. We focus on the middle reaches of the river, a transitional sector showing a mixture of European and African flora (*Salix* spp., *Fraxinus* spp., *Populus* spp., *Tamarix* spp., *Nerium oleander*). Taking the whole potential distribution of 92A0 habitat in the area, 52 restoration reaches were defined by considering closeness to natural habitats, presence of native remnants, vegetation dynamics, technical feasibility, social acceptance and synergies with ongoing projects. Restoration was assessed through a BACI design (Before–After Control-Impact). 16 sampling sites were annually monitored (in spring) for riparian vegetation (transects and plots), birds (transects) and aquatic macroinvertebrates (multihabitat standardised protocol),half of them located in sections with monthly and quarterly pruning, respectively. There, we recorded a set of ecological indicators for each sampling site/year: riparian vegetation richness, riparian quality index (González del Tánago and García de Jalón, 2011), density and height of *A. donax*, native and exotic vegetation cover,aquatic macroinvertebrate family richness and abundance, IBMWP (Alba-Tercedor *et al*., 2002), bird density and kilometric abundance index for birds. Changes in each ecological indicator among years (2015, 2016 and 2017) and treatments (monthly vs quarterly pruning) were tested using linear mixed-effect models (LMEs), considering year and type of treatment as fixed factors and sites as random factors. Tukey post-hoc tests were applied when significant results were found in LMEs. Homoscedasticity and normality of residuals were checked. All the analyses were performed using R.

3 RESULTS

As main findings, we observed a significant reduction of *A. donax* height ($p=3.77*10^{-13}$), an improvement of the riparian quality (p=0.005) and an increase in riparian species richness ($p=1.51*10^{-9}$), as well as aquatic macroinvertebrate quality (p=0.048), abundance (p=0.021) and family richness (p=0.023) through time (factor: date). According to Tukey post-hoc tests these changes mainly occurred two years after the execution of restoration measures. The frequency of pruning (type of treatment) had no significant effect (p>0.05) for any ecological indicator. No significant responses were found for bird abundance indicators (significant results are shown in Figure 1).

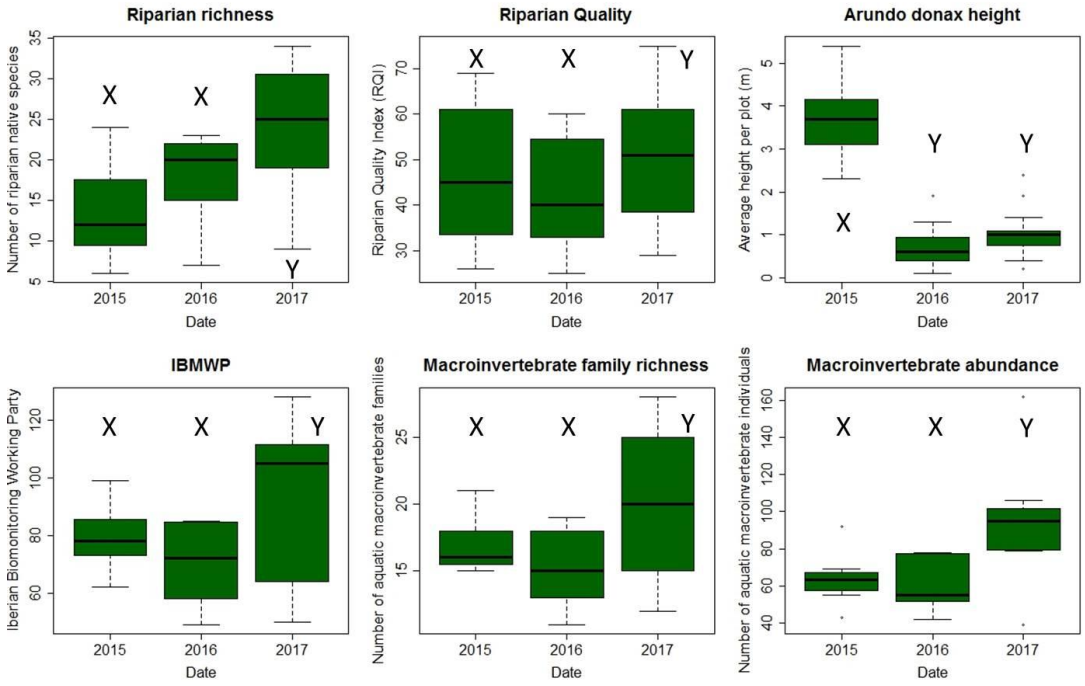

Figure 1. Boxplots showing significant changes (according to LMEs) of ecological indicators among 2015 (before restoration actions) 2016 and 2017. Different letters (X, Y) were assigned when dates showed significant differences in the Tukey post-hoc test. Horizontal lines represent the median, 25th and 75th quartile values.

4 CONCLUSION

Although some general improvement has been observed, the values of the ecological indicators used are still far from reference values so both the treatment and monitoring should be extended in time to reach satisfactory results. At the middle of the project and two years after starting restoration measures only slight changes in riparian vegetation and aquatic macroinvertebrates have been observed. As expected, riparian bird community seem to need a greater development of planted riparian species since they are highly influenced by the structural features of riparian vegetation. The current work contributes to improve adaptive management in this kind of projects with the objective of correcting the observed deviations and strengthen the positive effects found.

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