New Sélune River (Normandy, France) margins following large dam removal: ecological restoration perspectives considering the successional vegetation dynamics of alluvial deposits

Les nouvelles berges du fleuve Sélune (Normandie, France) en vue du démantèlement de grands barrages : potentialités de restauration écologique passive au regard des dynamiques végétales des vases exondées

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RÉSUMÉ

L'étude a été conduite entre 2015 et 2017 sur le fleuve Sélune (Normandie, France) dans le cadre du suivi scientifique accompagnant l'opération d'effacement de ses deux grands barrages, de 36 m et 16 m de haut, prévu à l'horizon 2020. Pour faciliter les travaux de gestion sédimentaire réalisés en parallèle de la vidange de la retenue de Vezins, le niveau du lac a été stabilisé à sa côte usuelle basse dès le printemps 2015. Depuis le printemps 2017, le plan d'eau est abaissé progressivement pour la mise en œuvre de ces travaux jusqu'à l'assec complet attendu à l'été 2018, libérant le lit majeur. Le démantèlement du barrage de Vezins débutera au printemps 2019. Des hectares de vases sont déjà recolonisés par la végétation et, en 2017, le lit originel du cours d'eau réapparait progressivement en queue de retenue. L'objectif de cette étude est d'analyser les stades de successions végétales dans le contexte d'un arasement de barrage selon trois axes : i) la dynamique des espèces colonisatrices à l'échelle de la retenue, ii) la spatialisation interne du processus et iii) l'accent sur les nouvelles berges du fleuve qui se sont dessinées en 2017 : il s'agira de prédire la capacité de la végétation à restaurer passivement la zone riparienne de la Sélune. La rapidité du processus de recolonisation et de l'évolution des successions ainsi que les dynamiques de successions observées sont discutées.

ABSTRACT

The present study is part of the scientific monitoring related to the removal, expected by 2020, of the two Sélune River dams (Normandy, France) –of 36m and 16m respectively. It was conducted between 2015 and 2017. In order to make sediment management easier during the emptying of the lake, the water level of the impoundment was stabilised at its usual lowest level since the spring of 2015. It has been slowly reduced since the spring of 2017 to conduct these operations until the completion of the emptying which is planned for the summer of 2018, allowing for the floodplain to progressively go back to its normal course. The dismantlement of the Vezins Dam will begin in the spring of 2019. Hectares of muds are already colonized by vegetation and, the original riverbed was reappearing in the upper parts in 2017. The aim of this study is to analyse the vegetation successional stages of dewatered sediment banks in the context of the dam removal. It focuses on three axis: i) the dynamics of the colonizing species at the scale of the emptied lake, ii) the spatial patterns of the process and iii) the new river margin sectors that reappeared in 2017. We will predict the vegetation's ability to passively restore the riparian area of the Sélune River. The fast colonization process, the extremely rapid evolution of successional stages and the spatial succession dynamics observed are treated.

MOTS CLES

Alluvial deposit, Dam removal, Passive ecological restoration, Riparian vegetation succession

1 INTRODUCTION

There is a lack of scientific monitoring related to the ecological restoration of river valleys for large dam removals. However, the ecological importance of the riparian ecosystems, highly degraded by human activities, has been widely studied. Following the European Water Framework Directive (2000), many floodplains have been restored (Rohde & al., 2005), especially by (small) dam removals owing to their impacts on hydrosystems and for economic/safety issues (Stanley & Doyle, 2003).

The Sélune project concerns a two large hydroelectric dam removal (Vezins, 36 m high; La-Roche-qui-Boit, 16 m high). They will be dismantled by 2020 according to the French government's decision to give way to 91 kilometers of reconnected river, opened for migratory fishes (*Salmo salar*, *Anguilla Anguilla*, etc.) and for the renaturation of more than 20 km of river stretch (lake's previous length). Since the spring of 2015, the usual 1m summer tidal range of the Vezins impoundment, related to the hydroelectric management, is not established anymore to make sediment management easier during the emptying of the lake. Hectares of dewatered muds were greening spontaneously during the following summer periods. Since 2017 and until the complete emptying expected in the summer of 2018, the water level of the reservoir lake is slowly being decreased to conduct these complex engineering works (prevention of sediment flooding). The lake is slowly being replaced by a new river meandering through new fields and wetlands colonized by a spontaneous vegetation. The aim of this study is to evaluate the vegetation's ability to passively restore the riparian area of the new Sélune River that is appearing after the lake emptying.

2 MATERIAL AND METHODS

The Sélune River (Normandy, North West of France) is coastal with a modest flow rate (11 m^3/s). It is 91 km long, and flows down into the Mont Saint-Michel bay. It drains a watershed of 1'083 km^2 fed by more than 500 tributaries in a diversified rural landscape. We focused on the Vezins impoundment (19 km long, 160 ha), where the new river is progressively appearing and about 20 tributaries flows.

The vegetation survey sampling, conducted between 2015 and 2017, is based on observations of spontaneous vegetation community colonizing alluvial deposits at two scales (impoundment/ experimental site). We considered 22 sites spread across the reservoir depending on their lateral and longitudinal position (top/bottom of the riverbanks, upstream/downstream, tributaries' mouths/Sélune's banks, rework/undisturbed areas,) and, in another hand, focused on the République Bridge experimental site (Fig. 1). 13 sites were sampled in March, June and September 2015; 18 in September 2017. The République Bridge site was sampled in March, May and July 2015 and in July 2016 and 2017.

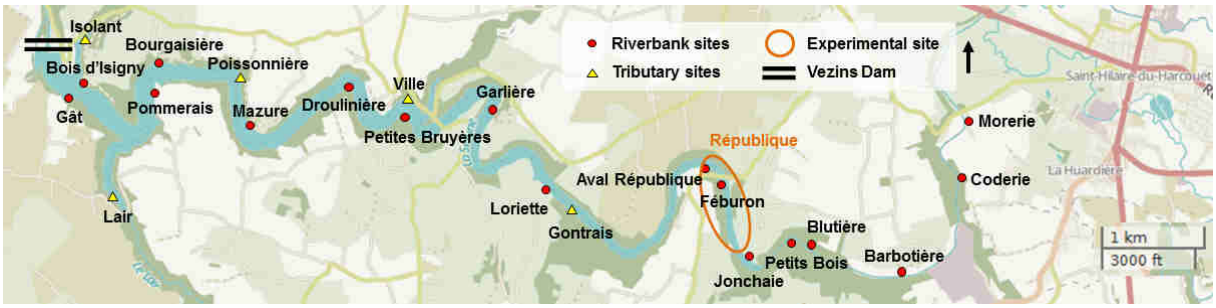

Fig. 1. Location of the 22 sites along the Vezins impoundment

In every sites, transects were designed on homogeneous strip of vegetation along the river. Three 1 x 1 m plots, one meter apart from each other, were sampled on each as well as some site conditions (bare ground, lateral distance from the river, downstream distance, edge ligneous species, etc.). We also made an exhaustive inventory in 4 stations. We analysed covering rate, diversity index (species richness, Shannon entropy, Evenness) and structure (NMDS ordination) to describe the colonization process. Each species was also statistically identified to its ecological group (Moser & al., 2002) summarized in forest, "agricultural" (ruderal, adventitious and meadow species) and wetland species. The influence of environmental variables was assessed (*ordisurf* function, *Vegan* R package).

3 RESULTS AND DISCUSSION

3.1 The dynamics of the colonizing species at the scale of the emptied lake

Since 2015 and after each water level decrease, a very fast colonization process was observed revealing the presence of a substantial viable seed bank:

- In one season, almost 100% of the alluvial deposits is recovered by vegetation at both scales.
- The impoundment is still free of the most problematic invasive plants after two years.
- Species richness and diversity rapidly increased in 2015, and then, stabilized.

We observed a terrestrialization process marked by a rapid successional change and shifts in vegetation composition (aquatic pioneer to terrestrial communities):

- The disappearance of aquatic and several marsh species begun in June 2015 and was more pronounced in 2017.
- Increase of richness and diversity on newly exposed deposits, with more agricultural species, at the site scale.

3.2 The spatial patterns of the process

By comparing numbers and proportions of taxa per ecological group between tributaries' mouths and other sites in 2017 (Fig. 2), we noticed a mosaic of habitats colonizing alluvial deposits:

- "Agricultural" species are dominant, followed by wetland species, except at the République Bridge site.
- Tributaries' mouths are richer and more diversified than other sites. If their ecological group composition is quite similar, they tend to host more "agricultural" species, suggesting a landscape influence through flow contribution.

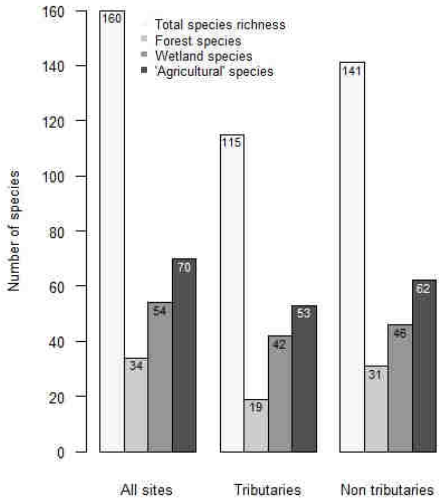

Fig. 2. Groups total richness – Sept. 2017

The process is structured in two internal gradients:

- A lateral effect: bank-top sediments are richer, more diversified and more covered by plants than bottom ones. Although they have a common pool of species, their structures tend to split with more ligneous species further away from the riverbed.
- A longitudinal threshold effect: upstream and downstream sites both have a common pool of species but their compositions tend to split. Downstream sites are characterised by more ruderal and adventitious communities because of their lower covering rates.

3.3 The new river margin sectors

By the end of 2017, the original riverbed was already reappearing and meandering in the upper parts. Moreover, few months after the sediment management operations, deposits were totally covered by vegetation and pounds had been naturally created. The set-up of an observatory of "innovative" ecological successions in restoration ecology is ongoing on these new interface habitats.

4 CONCLUSION

Our results concerning this unique renaturation project of an entire coastal river suggest a potential for passive new river margin restoration regarding colonization rapidity and patterns in the impoundment. We now have to analyze functional traits of the species and their ability to cover and maintain alluvial deposits. Moreover, the presence of "agricultural" species should be closely monitored given the possible reuse of sediments on agricultural plots. By continuing with the actual monitoring and by focusing on future river interface habitats through an observatory, we will be able to predict habitat mosaic, and then, to support the manager of the new valley.

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