Plant dispersal mediated by sheep pastoralism on the banks of the Loire River

DispersaL

BIOSEFAIR metaprogram

Project summary: 2024 – 2026

April 2026

The Loire River carries sediments laden with seeds from native and exotic plants, which are deposited during floods and receding waters cycles on the river margins. At the interface between aquatic and terrestrial environments, the DispersaL project investigated the impacts of sheep grazing (as part of the Pasto'Loire initiative) on areas managed by the CEN (Conservatoire des Espaces Naturels) Centre Val de Loire. The focus was put on the ecological processes associated with the presence of domestic herbivores on the spatial and temporal dynamics of the flora in grazed floodplains, in particular herbivory and zoochorous dispersal. Certain benefits of sheep grazing are well established, notably the maintenance of open habitats and log jams risk reduction, but the potential risks associated with the spread of exotic plants within areas renowned for their biodiversity, in landscapes classified as UNESCO World Heritage sites, are much less so.

We assessed riverine inputs across different components of the flora: the soil seed bank, the local expressed flora, the grazed flora and the sheep-dispersed flora. In parallel, and on the same sampling plots, we studied the entomofauna associated with pastoralism—which plays a role in the recycling of organic matter—over two annual cycles.

The aim of DisparsaL was to assess the consequences of pastoral grazing, i.e. successive grazed sites, on the endo- and epizoochorous dispersal cycle of native and exotic plants. We combined these *in situ* observations with an experiment conducted under controlled conditions using Romane breed ewes and ewe lambs reared at the INRAE P3R experimental unit in Osmoy. In this experiment, we tested the effect of animal sociality on the epizoochorous dispersal of *Xanthium strumarium*, an invasive alien species found along the banks of the Loire river. More specifically, we examined the effect of the ewe-to-lamb ratio within the group on the retention time and dispersal distance of this plant.

The aim of DispersaL is to provide insights into the dynamics of grazed vegetation in order to discuss adjustments to sheep grazing practices, taking into account factors such as grazing duration, flock size and plant phenology, with a view to reconciling socio-economic expectations with the ecological processes that shape vegetation. In conjunction with and as part of the DIASPORE project, funded by the APR IA of the Centre Val de Loire Region, the UMR Citeres carried out a component focusing on the views of various stakeholders regarding the benefits and drawbacks linking pastoralism, natural habitats, flora and entomofauna.

Detailed results

Cocklebur *Xanthium strumarium* is an invasive alien species found along the banks of the Loire River. It is now present along much of the river's banks. This plant produces fruits (containing two seeds) with hooks that facilitate their epizoochorous dispersal. However, these fruits are also carried by the river; they can float and thus be dispersed over long distances, explaining the current distribution of this plant along the Loire River. These fruits were indeed found in the majority of the sheep fleeces that we studied in 2024 (8 out of 12 fleeces) and 2025 (10 out of 12 fleeces). Our experiment with ewes and ewe lambs at the P3R experimental unit also demonstrated that these fruits can be dispersed by these animals over significant distances, exceeding two kilometres covered during six hours of observation. The conditions are in place for sheep grazing on sites where this plant is established to act as dispersal vectors for the spread of this species across the countryside. This plant may invade the landscape, along grazing routes dictated by the shepherd. The grazing system established at the Bonny-sur-

Loire islands site did not allow us to verify this. The change in grazing routes involving the herd's movement over greater distances (successive sites separated by several tens of kilometres) is therefore potentially problematic. Furthermore, this plant can retain its hooked fruits throughout the year, even after the plant has withered, and these fruits remain available for zoochorous dispersal outside the fruit and seed production period.

With regard to the effect of sociality, specifically the composition of the group (the relative proportion of ewe lambs in the group), our experiment showed that as this proportion increased, both the retention times and the dispersal distances of the fruits decreased. This is explained by more frequent contact between individuals, as well as more frequent individual grooming by ewe-lambs. Ewe lambs tend to lose the fruits caught in their fleece more easily. During these contacts between individuals, we also observed more frequent transfers of fruits as the proportion of ewe lambs in the group increased. These transfers generally weaken the adhesion of the fruits to the animals' fleece, facilitating their subsequent detachment. From a practical perspective, managing mixed herds comprising adults and juveniles tends to reduce the dispersal distances of this plant's fruits.

We recently tested this hypothesis by comparing groups of equal size, comprising three mother-offspring pairs, with groups consisting of three adults and three unrelated juveniles (using the red deer as model species), the mother-offspring bond leads to more frequent contact between individuals, with faster fruit loss in comparison with groups without kinship between adults and juveniles.

Examination of 12 fleeces in 2024 and 12 fleeces in 2025 collected during shearing revealed a wide variety of species dispersed within the animals' coats, 35 different species belonging to 10 families and 31 genera. We found between 3 and 13 different species per fleece, and between 8 and 377 seeds of a single species per fleece. These results confirm the high potential of sheep as epizoochorous vectors. Among this array of species, we found a cultivated plant, *Triticum aestivum*, an invasive alien species, *Xanthium strumarium*, and six archaeophytes. The proportion of non-native plants is quite low; however, the characteristics of the diaspores found in sheep fleeces suggest that a large proportion of the local flora could be carried in the sheep fleeces.

Regarding the proportion of flora dispersed by endozoochory (following seed ingestion and dissemination via faeces), samples were collected but were not analysed due to a lack of time and resources.

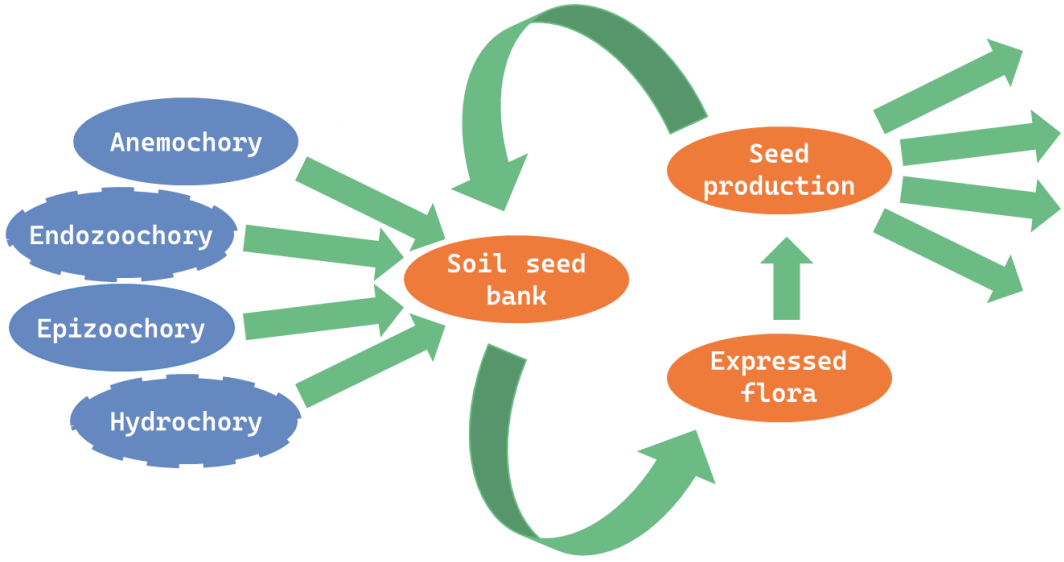
This aspect was assessed indirectly by combining herbivory pressure (using exclosures plots) with the phenological stage of the plants consumed.

The study of herbivory on the flora was carried out in 2024, a year in which the Loire experienced four (exceptional) episodes of flooding. This resulted in a two-month delay in the arrival of the ewes on site (in June), whereas the shepherd usually brings his flock at the time of lambing in April. This had the effect of greatly reducing the observation period. Furthermore, the shepherd's demarcation of grazing paddocks to optimise the flock's use of the resource and allow it to regrow after a change of paddock severely constrained our sampling, as the animals remained in each paddock for no more than ten days. We used 12 pairs of plots with a fenced/unfenced design within each successively grazed pasture (3 pastures studied) to determine the effect of grazing on species diversity, coverage and height of each species. The phenological stage (growth, flowering and fruiting) of each plant was also recorded to assess whether plants were consumed whilst bearing fruits and thus when they could potentially be dispersed by endozoochory. We identified 119 taxa, including 104 species; of these, 45 taxa,

including 40 species, were present at the seed stage. We observed little feeding selectivity, with grazing having a significant effect, leading to a reduction in biomass (coverage per species), maximum plant height, species density and the Shannon diversity index on the 1 m² plots. The stocking density present in each of the paddocks over a period of around ten days exerts a grazing pressure that very rapidly reduces food availability and therefore necessitates a regular transfer from grazed to ungrazed areas.

The study of the soil seed bank was conducted by UMR Citeres on the same network of plots as those used for the study of grazing pressure. It involved germinating soil cores (8 cores per plot) to identify the species present and capable of germination. 117 taxa were identified, the majority at species level. 5,500 individuals germinated, with 5 species accounting for more than half of the germinations (Portulaca oleracea, Urtica dioica, Lindernia dubia, Digitaria sanguinalis and Cyperus fuscus) and very few exotic species. Seed fall, i.e. the proportion of plants whose diaspores fall to the ground, is virtually negligible compared to the expressed flora and the soil seed bank, averaging around 4 species per plot.

A comparison of these three components of the flora shows that the expressed flora is distinct from the soil seed bank, but that seed fall helps to explain part of the expressed flora. The contribution of flora dispersed by sheep via epizoochory and endozoochory (samples collected but not yet identified) to explaining the expressed flora, in particular, remains to be investigated as part of the DIASPORE project.



The study of the coprophagous entomofauna from April to October in 2024 and 2025 identified 39 species that depend in part on the presence of sheep on site to complete their life cycle. Roe deer and wild boar are also present on site and can produce the resources upon which these coprophagous insects depend, but in much smaller quantities. The presence of sheep grazing along the banks of the Loire therefore sustains rich communities of coprophagous beetles involved in the recycling of the organic matter. These field data will be added to existing databases and will be valued in collaboration with the Eco-Entomology Laboratory, which carried out the identifications. Some of the identified species are subject to conservation status.

Scientific perspectives.

Following this project, using the GPS trackers employed in the experiment at UE P3R, we would like to track the daily movements of ewes and ewe lambs directly on the Bonny-sur-Loire islands to assess the characteristics of individual movements and determine how much of the area is actually used by the animals. The partnership with the shepherd allows us to explore this.

It would also be interesting to be able to track the flock on grazing routes including relatively distant sites (such as during transhumance routes).

Dispersal 2024–2025 is linked to the DIASPORE project (funded by the Centre-Val de Loire Region under the APR IA 2023–2026 program) and to the funding of a half PhD scholarship with the University of Angers (2024–2027). This PhD enables us to continue our fundamental research into the role of animal sociality into zoochorous dispersal, which represents a frontier in dispersal ecology research. In particular, in this PhD, we will assess the effect of group composition and group size using two deer species housed at the Haute Touche Zoological Reserve (sika deer and red deer).

Roux A, Balson C, Audiguier M, Battista M, Marcon D, Pays O, et al. Age ratio in groups of a social ungulate affects epizoochorous dispersal and diaspore exchanges. Oikos. 2026: e11894. https://doi.org/10.1002/oik.11894