MEASURING AND MODELLING PLANT TRAITS IN FLOODPLAINS OF REGULATED RIVERS

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1 INTRODUCTION

In floodplains, the succession of vegetation towards its climax stadium can be reset, delayed or ceased by abiotic and biotic processes [1]. At century scale, vegetation in floodplains of free flowing rivers may mature into floodplain forests, but are eventually reset to bare sediment. Vegetation in floodplains of regulated rivers are *not* exposed to the fierce sedimentation and erosion powers of free flowing rivers. Therefore, the riparian vegetation along these rivers likely reaches the climax stadium if no measures are taken [2].

Moreover, unlike the floodplains of free flowing rivers, the floodplains of regulated rivers often need to fulfil several law-enforced ecosystem services, like providing water safety during high river discharges and as nature areas. Unfortunately, combining several ecosystem services is complex and puzzles floodplain managers [3]. Increasing the understanding of how abiotic and biotic processes (hereafter: filters, sensu Keddy [4]) shape floodplain vegetation patterns and influence succession rates, may facilitate floodplain management of regulated rivers. Plant traits are characteristics needed to establish a population under specific conditions and link filters and vegetation composition [5]. Moreover, plant traits can be a useful concept in revealing the dominant filters in shaping patterns, senescence and rejuvenation of floodplain vegetation.

Specific traits or trait composition (i.e. a strategy) have been coupled to various riverine processes such as flooding and drought cycles (e.g. [6] [7]). For example, shorter time between floodings, together with the timing and longer duration of a flooding, steer towards species with shorter lifespan, while longer time between floodings and floods with shorter duration select for species with longer lifespan [6] [8]. Another example is Raunkiaer’s life forms [9], as those are good predictors of oxygen and drought stress [10].

However, as Reich [11] pointed out, the back bone of trait selection is the fast-slow continuum (a.o. the leaf economic spectrum (LES)). This continuum refers to the slow or fast use of all resources (nutrients, light and water), even though probably only one resource is limiting, and its alignment with either slow or fast metabolic rates (e.g. photosynthesis, respiration). For example, species thriving under low water availability have also low uptake rates of nutrients and low metabolic rates compared to species that do well in high competitive settings. Any additional filters to this slow-fast continuum selection on traits just modify those traits.

In the floodplains of the regulated large rivers in the Netherlands, filters such as substrate type, and hence water and nutrient availability, flooding characteristics, and grazing pressure act on trait composition. Combining those filters with international literature on plant traits, resulted in the conceptual framework of those floodplains (Figure 1).The present field study was carried out to 1) test this theoretical framework, and 2) find out if the various filter-trait relations differed spatially. By combining field data and literature knowledge, a model is being developed to serve as a vegetation development tool in floodplains of regulated rivers.

2 MATERIAL AND METHOD

2.1 Fieldwork

In 2016, in each of three Dutch floodplains (Duursche Waarden, Erlecomse Waard, Millingerwaard), ten non-woody 1 m^2 plots were marked. The following proxies of filters were measured: meters above mean river level

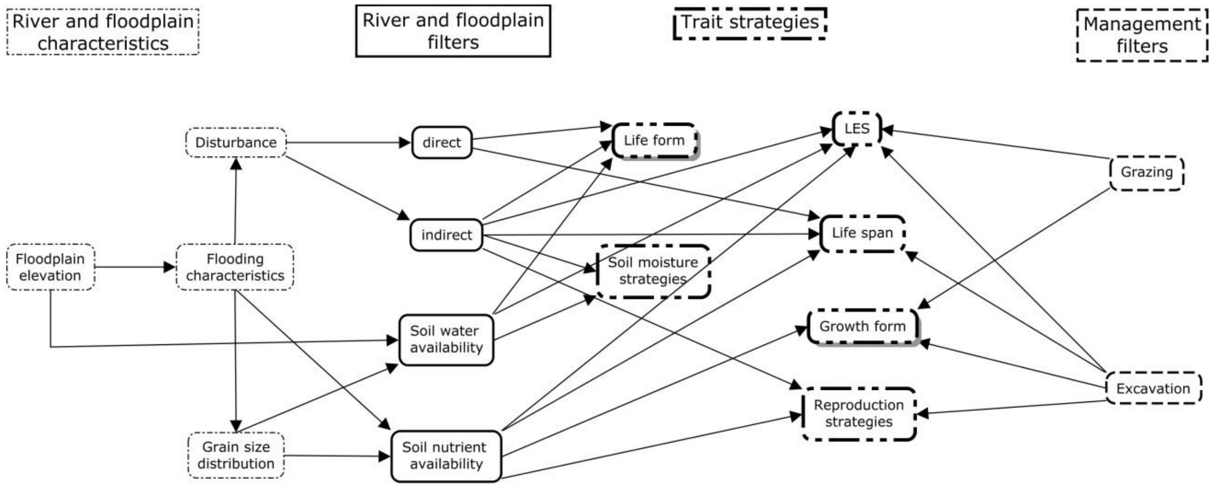

Figure 1: Conceptual framework of filters and traits. The boxes on the top indicate the group to which the similarly bordered boxes in the network belong to. The arrows indicate the effect of a characteristic on a filter or indicate connection between filter and trait or trait strategy.

(Elev, m), soil moisture (SoilM, %), soil organic matter content (L550, %), grain size (lutum, silt, fine and coarse sand), and being flooded during the summer of 2016 (Flooded, y/n), excavated (Exc, y/n) and/or grazed (Grazed, y/n). The vegetation was mapped with the Braun-Blanquette method and of the species covering over 15% of a plot, the traits making up the leaf economic spectrum (LES, dry weight (g), surface area (m^2)) and leaf N (LeafN, g/g)) were measured. The Turboveg software supplied the trait values for life history, life form, growth form, soil moisture and reproduction strategies for all the mapped plant species.

The proxies and leaf traits were analysed using principal component analysis (PCA) to reveal the dominant steering processes and to test if the measured leaves agreed with the LES. Fuzzy c-means clustering [12] was used on both proxies and traits to identify possible coherent relations between proxies and traits. Next, multiple regression trees (MRTs), with the proxies as constraining variables, were constructed to identify possible direct relations between proxies and traits [13].

2.2 Modelling

To construct tailor made relations between filters, traits and ecological functioning of floodplains of regulated rivers, literature findings and field data are combined. To start, these relations will be constructed for three distinct trait compositions under dry, competitive and moist conditions. Calibration of the relations, which will be mathematically solved by means of linear optimization, will be performed with LES field data. Validation is to be done with field data that is still to be collected. Next, additional filters, such as excavation, grazing, flooding, and succession, will expand the model. Finally, the model will be extended with more specialized strategies, like typically growth and life forms, and life span to be able to analyze different ecological functioning and hence ecosystem services.

3 RESULTS

3.1 Fieldwork

The first PCA axis explained 63.7% of the variance and grouped SoilM, Lutum, Silt, Elev and L550. The second PCA axis explained 20.1% of the variance and coincided with Exc and fine sand. Fuzzy c-means clustering indicated that there were no coherent relations between proxies and traits, and thereby indicated that other processes, such as chance, grazing intensity or starting conditions, can also be important filters. The results of the MRTrevealed that Elev, SoilM and Exc were the most influencing variables for trait composition: Elev selected for acquisitive species in lower areas and conservative species in higher areas due to both water and nutrient availability or scarcity (partly shown in Figure 2). SoilM filtered on traits to cope with wetter conditions, and selected for differences in the onset of flowering, indicating differences in competition strength. Exc influenced life span and growth form by initiating secondary succession.

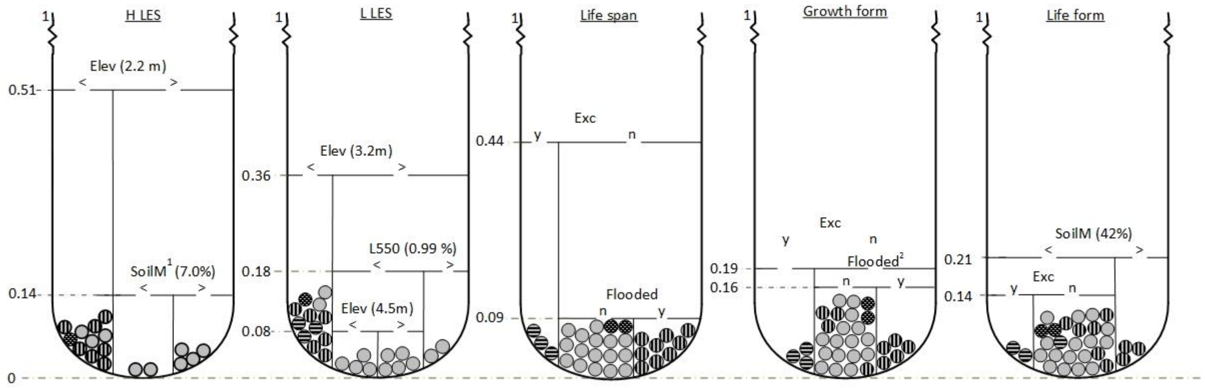

Figure 2: Overview of part of the summarized MRT results for LES (2 categories: high (H) and low (L) Nleaf content), Life span, Life form, Growth form and Life form. The left axes represent the explanatory power of the filters on the trait composition: 0 means 'explains nothing', 1 means 'explains all'. The horizontal lines indicate a filter (for example 'Elev') including its threshold value. Vertically striped circles represents plots that were flooded in the summer of 2016, horizontally striped circles excavated plots and black circles non-grazed plot. Superscripted number indicates another filter with the exact same result: 1: L550 (0.94%), 2 SoilM (33.8%).

3.2 Modelling

The modelling part is still in its early stage of development, but Figure 3 shows the preliminary assumed relations between filters, traits and photosynthetic rate for the three different strategies.

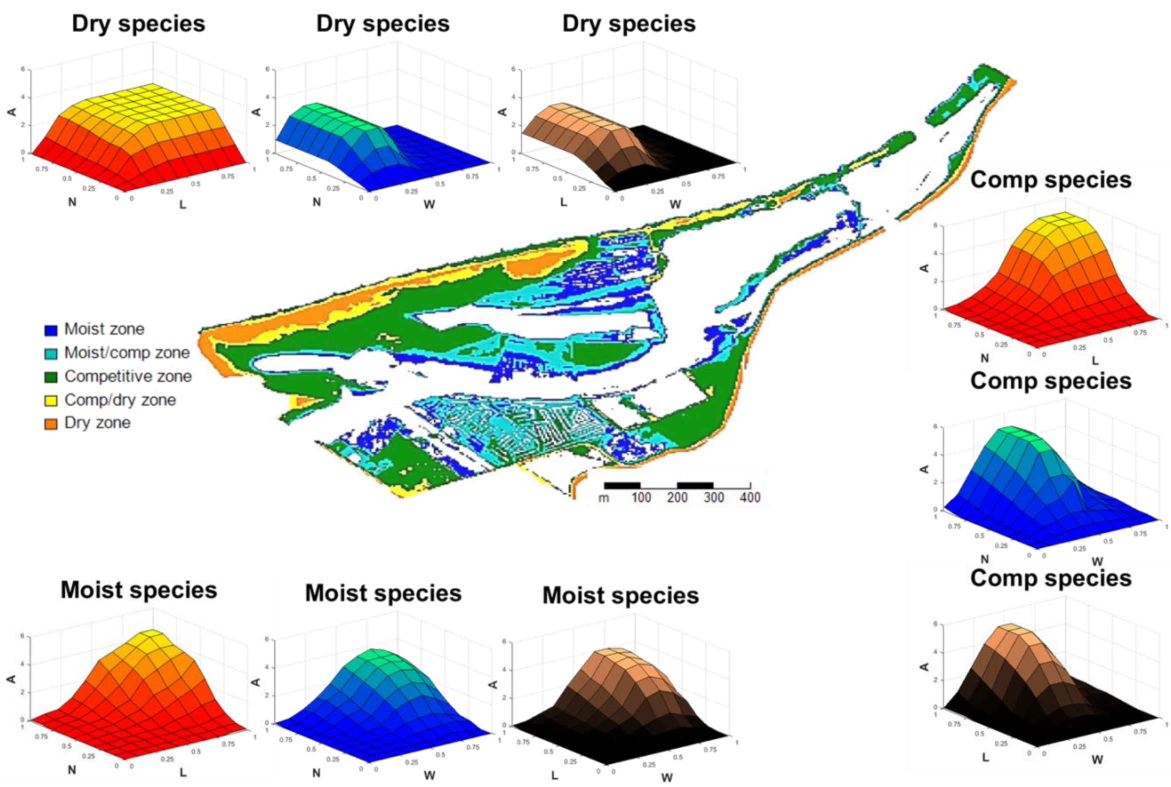

Figure 3: Preliminary relations between nutrients (N), light (L), water (W) and photosynthetic capacity (A) for dry, competitive and moist species. The axes represent indices, not yet real values. The axes scaling is uniform. The figure in the middle is the bathymetry of the Duursche Waarden, one of the research floodplains, the legend of the left hand side explains the different zonation within the floodplain and the zonation links to the areas where each of the three species types dominate.

4 CONCLUSION

Despite the lack of steep mechanical gradients in floodplains of regulated rivers, the trait concept proved to be an aid in understanding how filters shape vegetation composition spatially. The elevation reflected the slow-fast continuum, while excavation and flooding intervened with the senescence and rejuvenation of the vegetation. Eventually, the modelling will further the understanding of the importance of the filters on trait composition and will serve as an interpreter for spatial and temporal ecological functioning and hence the ecosystem services floodplains of regulated rivers can fulfil.

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