FINDING SIGNIFICANT AND INSIGHTFUL RELATIONSHIPS BETWEEN BIOTIC AND ABIOTIC FACTORS IN ATLANTIC RIVER CORRIDORS

Fernández-Iglesias, E.[1]; Fernández García, M.[1]; Sanna, M.[2]; González-Rodríguez, G.[3]; Valderrábano Luque, J.[2]; García Manteca, P.[2] & Marquínez García, J.[1,4]

1 Geomorphology area in Natural Resources and Planning Territory Institute (INDUROT). University of Oviedo, Asturias, Spain
2 Plant conservation area in INDUROT. University of Oviedo, Asturias, Spain
3 Associate Professor of the Department of Statistics / INDUROT. University of Oviedo, Asturias, Spain
4 Head of INDUROT and Full Professor of Department of Geology. University of Oviedo, Asturias, Spain

life fluvial LIFE16 NAT/ES/000771

Indurot Instituto de Recursos Naturales y Ordenación del Territorio

Universidad de Oviedo / Universidá d'Uviéu / University of Oviedo

12th International Conference of the ERCIM WG on Computational and Methodological Statistics (CMStatistics 2019)
14-16 December 2019, Senate House University of London, UK

1 INTRODUCTION

River corridors are exposed to biotic pressures as invasive species and plant diseases and abiotic pressures as the intensification of uses, artificial structures and human activities. These pressures affect their functions and conservation, causing the deterioration and fragmentation of river habitats, particularly the priority habitat 91E0* Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior* (Directive 92/43/EEC on the conservation of natural habitats and of wild fauna and flora), are considered a key element in maintaining the structure and functionality of the river corridors.

LIFE Fluvial project improves the state of conservation of Atlantic river corridors in the Natura 2000 Network. The action area of the project is in eight protected areas in the NW of the Iberian Peninsula (Spain and Portugal). This work is focused on 7 areas located in Eo fluvial basin.

In the preparatory activities, a diagnosis of the initial river corridor situation has been carried out. Mapping and quantification of abiotic (edaphological, geomorphological) and biotic characteristics (alien species, dead alders and presence of representative alluvial forests species) have been collected through the LIFE Fluvial action areas located in the Eo river in the NW of the Iberian Peninsula (Figure 1).

In this work, the correlation among these biotic and abiotic factors is analysed for a better understanding of alluvial forest dynamics.

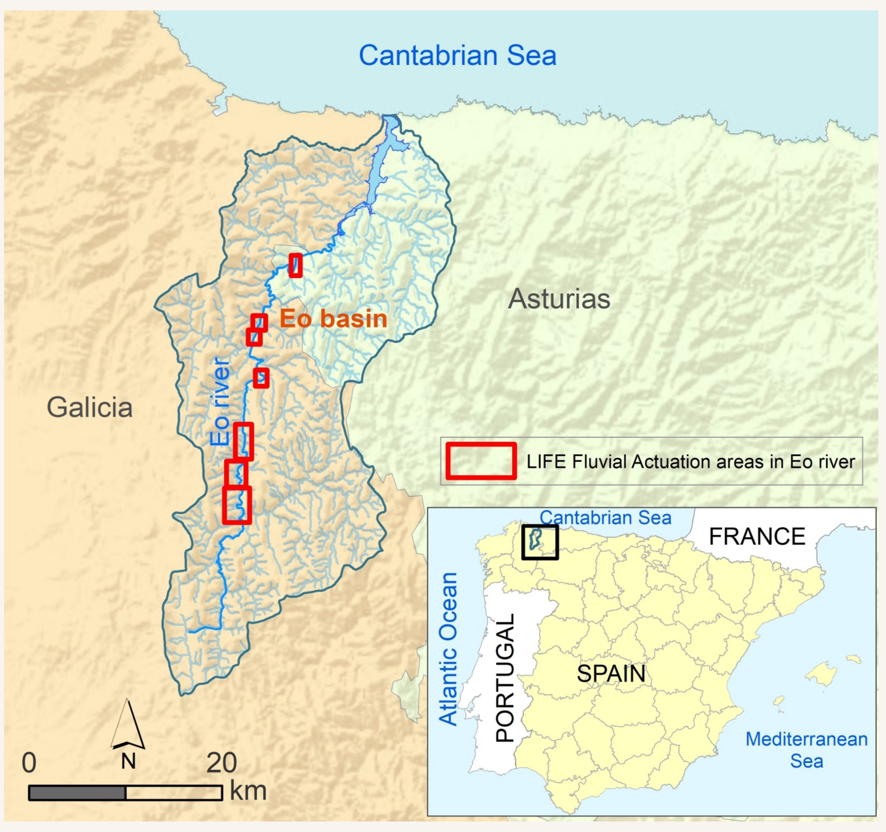

Figure 1. Eo basin and LIFE Fluvial action areas in Eo river.

2 AIM

How do hydrogeomorphological and soil parameters affect alluvial forest vegetation, the behaviour of alien species and alder disease?

3 APPROACH

About 40 data for each variable were obtained in the 7 action areas of LIFE Fluvial project located along 56 km of Eo river. Different hydrogeomorphological abiotic variables such as the size of the river basin, sinuosity index, valley confinement index, flooding, presence of recent flood evidence, erosion, anthropic elements (channelizations, bridges, weirs...) were measured in field. Additionally, 41 soil samples were collected and analysed in the laboratory to calculate pH, percentage of organic matter and electric conductivity.

Biotic variables collected are the number of alien species and their abundance, density of dead alders (*Alnus glutinosa*) by the *Phytophthora ×alni* phytopathogen and the number of typical species of alluvial forest inventoried in each action area. Figure 2 shows some examples of these variables in the Eo river. After a preliminary analysis, only the variables showed in Table 1 have been selected to compute the Spearman correlation/correlation coefficient and to apply multiple linear regression analysis (MLR). The aim is to get knowledge about relationships between them and to be able to predict the behaviour of the vegetation variables based on the others.

Table 1. Selected hydrogeomorphological, soil and vegetation variables for the analysis.

HYDROGEOMORPHOLOGYCAL VARIABLES	
Drainage area	Enclave catchment area
Recent flood deposits number	Number of recent flood deposits in the enclave: sand, gravel and flosam wrack (organic deposit like waffle, branches…) in the enclave
Sinuosity index	Length of the channel (thalweg) in the enclave divided by shortest distance between start and end of the enclave
EDAPHOLOGYCAL VARIABLES	
% organic matter	Percentage of organic matter in soil samples of the enclave
VEGETATION VARIABLES	
Alien species density	Number of alien species divided by enclave area
Alien species area	Area occupied by alien species divided by enclave area
Dead alders density	Number of dead alder by *Phytophthora* sp. divided by enclave area
Typical species number	Number of typical species of alluvial forest (habitat 91E0*) calculated in monitoring plot (a representative portion of the enclave area)

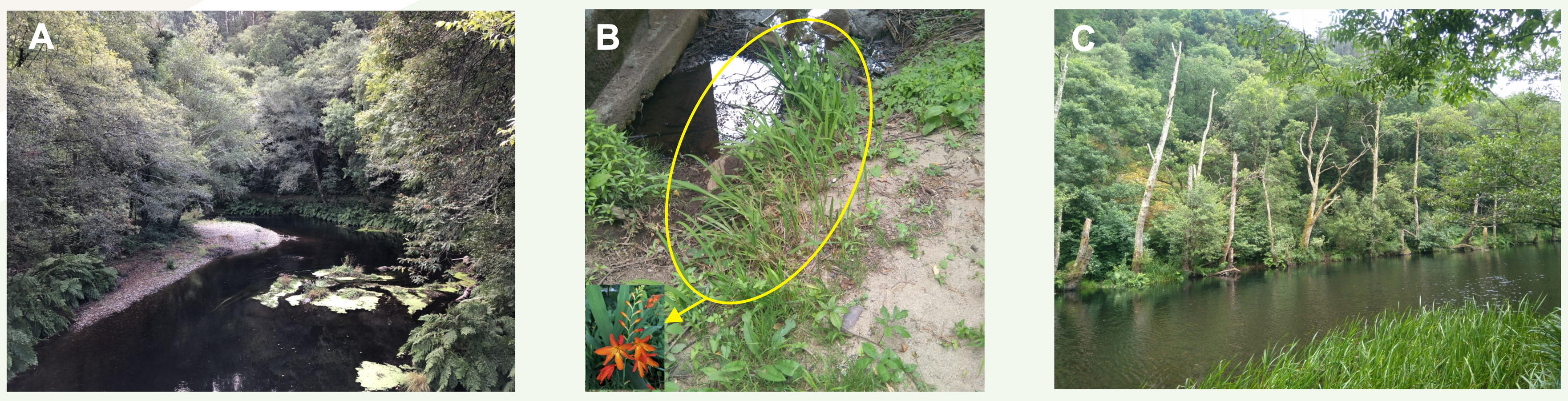

Figure 2. (A) Eo river corridor in a curved reach with a well-preserved alder trees (habitat 91E0*); (B) *Crocosmia ×crocosmiiflora* alien plant (yellow mark) on a layer of recent flood deposits (sands); (C) Dead alders by *Phytophthora* sp. in the channel boundary.

4 RESULTS

Results of nonparametric correlation analysis between abiotic and biotic variables are graphically represented in Figure 3. Correlation coefficient values higher than ±0.5 are considered as relevant.

The higest positive correlation coefficient is +0.85 and negative is -0.75. The lowest correlation is -0.02.

Alien species density variable is negative correlated within the drainage area (-0.6) but positive correlated with sinuosity index (+0.71). Seeds and plant fragments with vegetative capacity accumulate in areas where the river reduces its energy (hight sinuosity) and colonize these areas as a pioneer species (Gurnell & Grabowski, 2016).

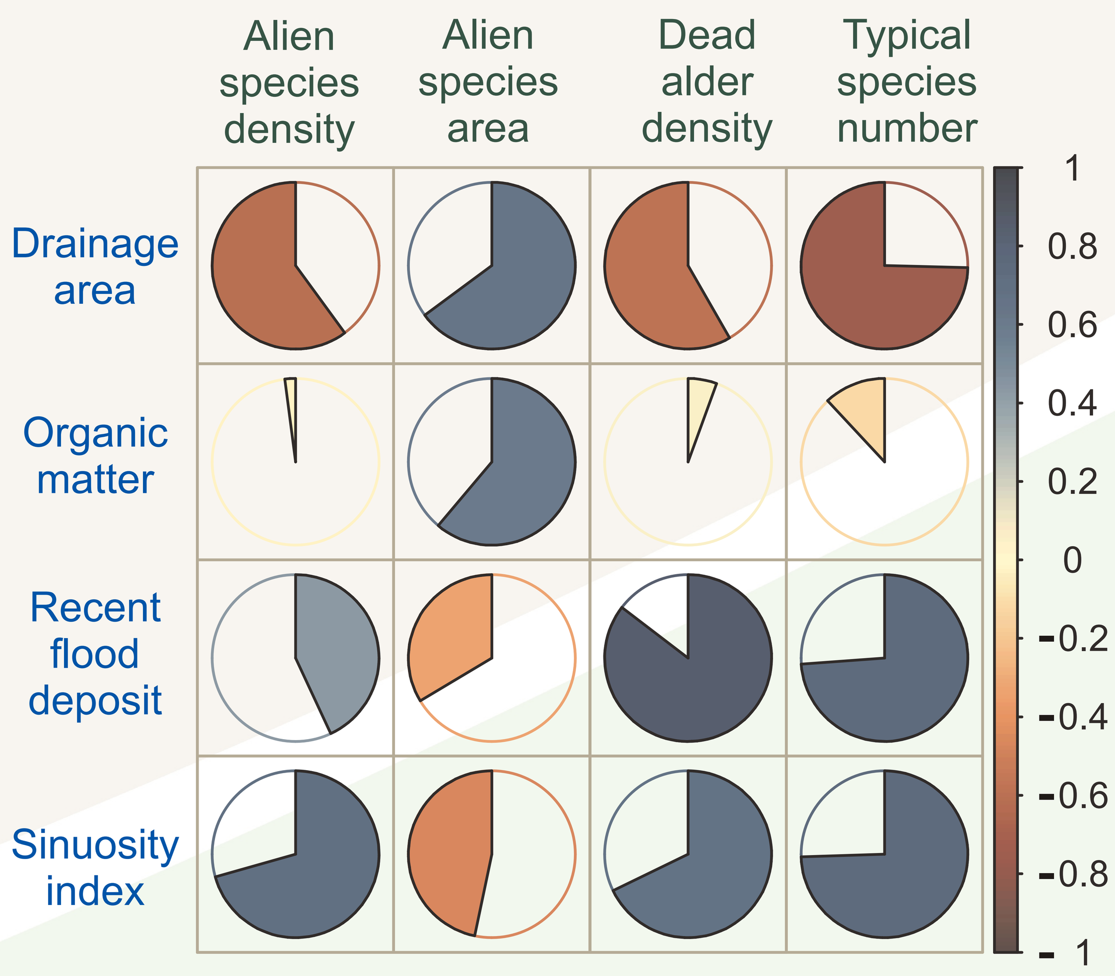

Figure 3. Results of correlation analysis.

Alien plants invaded areas is the only variable that positively correlates (+0.61) with the percentage of organic matter in the soil. Plants increase their growth in rich organic soils. Alien plants with an invasive behaviour as *Tradescantia fluminensis* or *Crocosmia ×crocosmiiflora* can grow faster than auctoctonous plants.

Highest positive correlation (+0.85) has been obtained between the **dead alders density** and the presence of recent flood deposits, according to the results of Strnadová *et al.* (2010), who determined that the alders stressed by flooding, suffer more damage by *Phytophthora* sp.

The correlation between the **number of typical species** and the drainage area was the highest negative one (-0.75). Anthropic alterations and land use are concentrated in the lower part of the Eo river, with a resulting lost of biodiversity.

A linear multiple regression analysis (MLR) was carried out combining all the abiotic variables for each biotic variable. Figure 4 shows the analysis with the highest multiple R-squared obtained (0.82). The response variable is **dead alders density** and the explanatory variables are drainage area, the presence of recent flood deposits and the organic matter.

Percentage of organic matter variable combined with presence of flood deposits and the drainage area are useful to explain and predict the dispersion of *Phytophthora* disease in alders and consequently his death.

```
Call:
lm(formula = D.DEADALDER ~ DRAINAGEAREA + OM + FLOODDEPOSIT, data = Life)

Residuals:
        Min          1Q      Median          3Q         Max 
-0.013040510 -0.007079562 -0.002904845  0.007904421  0.026849723 

Coefficients:
                 Estimate    Std. Error  t value   Pr(>|t|)    
(Intercept)    2.022927e-02  7.841760e-03  2.57969 0.01399626 *  
DRAINAGEAREA  -4.088861e-05  1.403194e-05 -2.91397 0.00602294 ** 
OM             1.436373e-03  3.663481e-04  3.92079 0.00036787 ***
FLOODDEPOSIT   1.870551e-03  2.102481e-04  8.89688 1.0039e-10 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 0.01046108 on 37 degrees of freedom
Multiple R-squared:  0.8184864, Adjusted R-squared:  0.803769
F-statistic: 55.61381 on 3 and 37 DF,  p-value: 8.779415e-14
```

Figure 4. Results of multiple lineal regresion of variable “dead alders density”.

Others interesting MLR analysis are: the **number of typical species** explained within drainage area, organic matter and flood deposit (Multiple R-squared: 0.73) and the **alien plants area** explained with drainage area and organic matter (Multiple R-squared: 0.58).

5 CONCLUSIONS

In this preliminary work, we have carried out a correlation / Spearman analysis that, in a simple way, has allowed us to know the relationship between hydrogeomorphological, soil and vegetation variables measured in field in the Eo River (NW Spain). On the other hand, a multiple linear regression has been carried out with the objective of predicting the behaviour of alluvial forest based on the abiotic variables.

As expected, a strong correlation among the density of dead alders with high flooding (+0.85) and sinuosity (+0.68) was found. In these areas, the oomicete *Phytophthora ×alni* can infect better the alders through the wounds caused by the trunks or the sediments carried by the current. Multiple linear regression shows that the 82% of variability of dead alders density is explained by a lineal relation with flood deposits, drainage area and percentage of organic matter.

The 73% of variation of the number of typical habitat species is explained by its linear relationship with the drainage area and the presence of flood deposits. These variables also show a high correlation with typical species, -0.75 and +0.74, respectively. Many of these riverside plants are adapted to the rapid colonization of bare soils affected by frequent flooding.

The variables related to the alien species show lower regression values, however they present different correlations that allow validating the fact that where the basin is larger, there is a greater anthropic incidence, which improves the presence of alien plants species from agriculture and gardening.

The relationships between abiotic and biotic factors are undeniable in rivers, however, there are many aspects affecting river corridors and their functioning: climatic conditions, plants dispersal vectors, anthropic factors, etc. All of them are part of a complex network of relationships that make up the river system and that statistical models can help to predict.

REFERENCES

Gurnell, A. M., & Grabowski, R. C. (2016). Vegetation–hydrogeomorphology interactions in a low-energy, human-impacted river. *River Research and Applications*, 32(2), 202-215.

Strnadová, V., Černý, K., Holub, V., & Gregorová, B. (2010). The effects of flooding and Phytophthora alni infection on black alder. *Journal of Forest Science*, 56(1), 41-46.

AKNOWLEDGEMENTS. This research was carried out within the framework of the LIFE Fluvial project (LIFE16 NAT / ES / 000771), *Improvement and sustainable management of the river corridors of the Iberian Atlantic Region* (2017-2021) of the European Commission