RIPARIAN VEGETATION RESPONSES TO HYDROMORPHOLOGICAL ALTERATIONS IN MEDITERRANEAN SYSTEMS:

Examples from Greek National River Monitoring Network

[WFD 2000/60/EE]

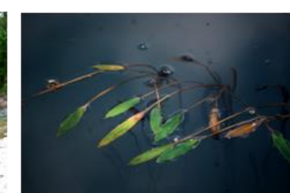
Eva Papastergiadou

& **Patras Freshwater Team,**

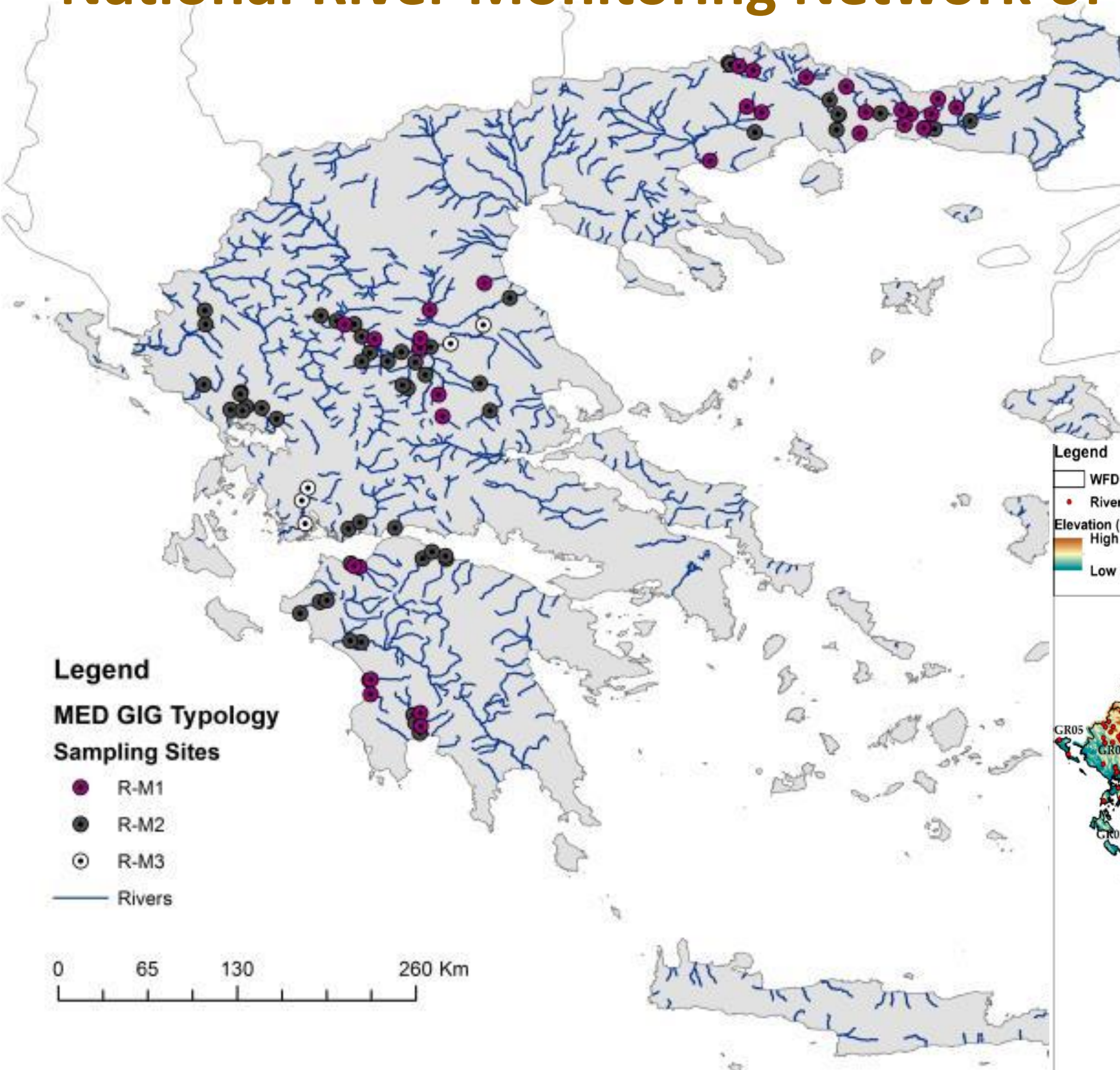
Dept. of Biology, University of Patras, Greece



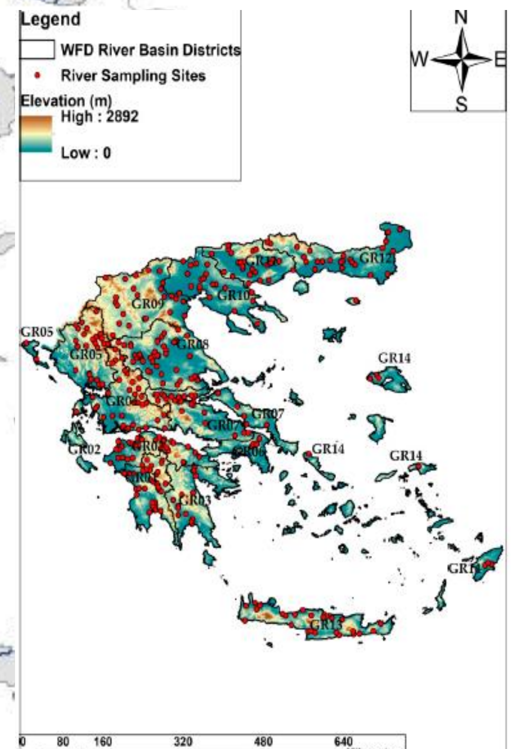


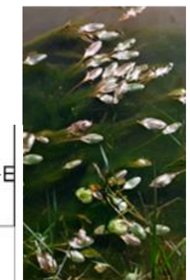


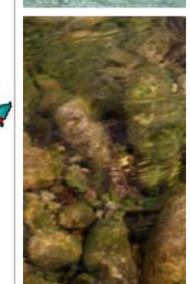
National River Monitoring Network of Greece



- Dense river network
- Few bigger rivers
- Important Transboundary rivers, North Greece
- NATURA 2000 – 22% of the country territory







Arkoudorema stream,
Mt Rhodope

Nestos River, Rhodope Mt

Nestos River,
Stavroupoli Bridge, Stena

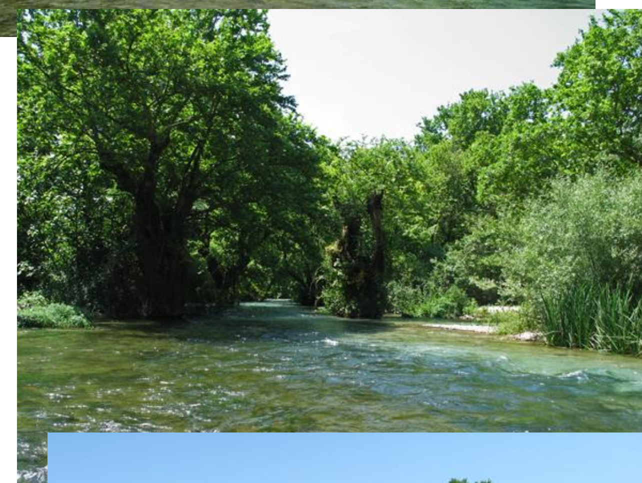

Axios
Transboundary River

Acheron River Gorge’s

Kallipefki stream, Mt Olympus

National River Monitoring Network

Code	**Riparian Forest Habitat types in Greece /**NATURA 2000 sites		
91E0*	Residual alluvial forests *Alnus glutinosa* & *Fraxinus excelsior*		
91F0	Mixed oak-elm-ash (*Quercus robur, Ulmus laevis, U. minor, Fraxinus excelsior, F. angustifolia)* forests of great rivers	**3.1.1**	**Broad-leaved forests**
92A0	*Salix alba & Populus alba galleries*		
92C0	*Platanus orientalis* & *Liquidambar orientalis* woods		
92D0	Thermo-Mediterranean riparian galleries (Nerio-Tamaricetea & Securinegion tinctoriae)		



Source: *Papastergiadou et al*. **2014, 2016, 2019**

Riparian Vegetation responses to specific hydromorphological pressures in Mediterranean rivers

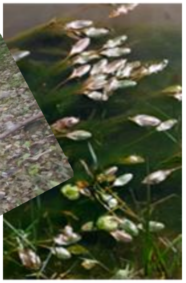
Fluvial geomorphological processes are known to significantly influence the **structure** & the extent of the ***riparian vegetation***.

Alterations in ***flow regime*** & the ***hydromorphology*** are often responsible for

-changes in the ***riparian plant community,***

-narrowing of the **riparian buffer zone** &

-***loss*** of **longitudinal connectivity**.

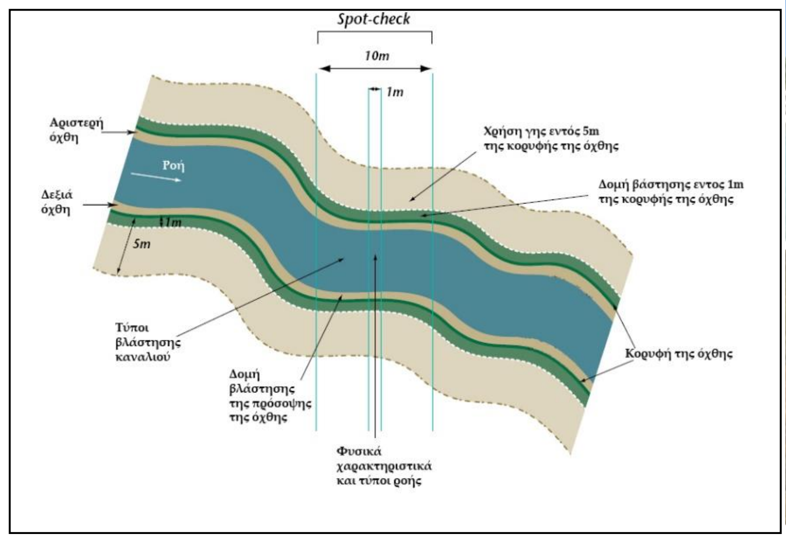


Riparian Vegetation responses to specific hydromorphological pressures in Mediterranean rivers

Hydromorphological *features & modifications* were assessed in a network of more than

100 river reaches distributed among **14** WFD River Basin Districts (**RBDs**) in Greece [*National River Monitoring Programme*], to identify the ***main drivers*** of *hydromorphological perturbation*.

We employed the **River Habitat Survey (RHS)** & we recorded hydromorphological features & modifications in both ***banks*** & the ***channel bed*** along **500 m** for each **river reach.**



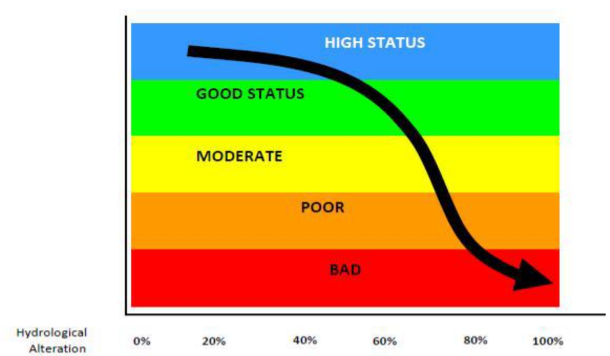
River Reach Scale: Hydromorphological pressures - **Habitat Modification Score (HMS)**

& the individual sub-scores that indicate ***the extent of specific modifications***

e.g. bridges, fords, weirs, bank reprofiling, bank reinforcement etc. were calculated in order

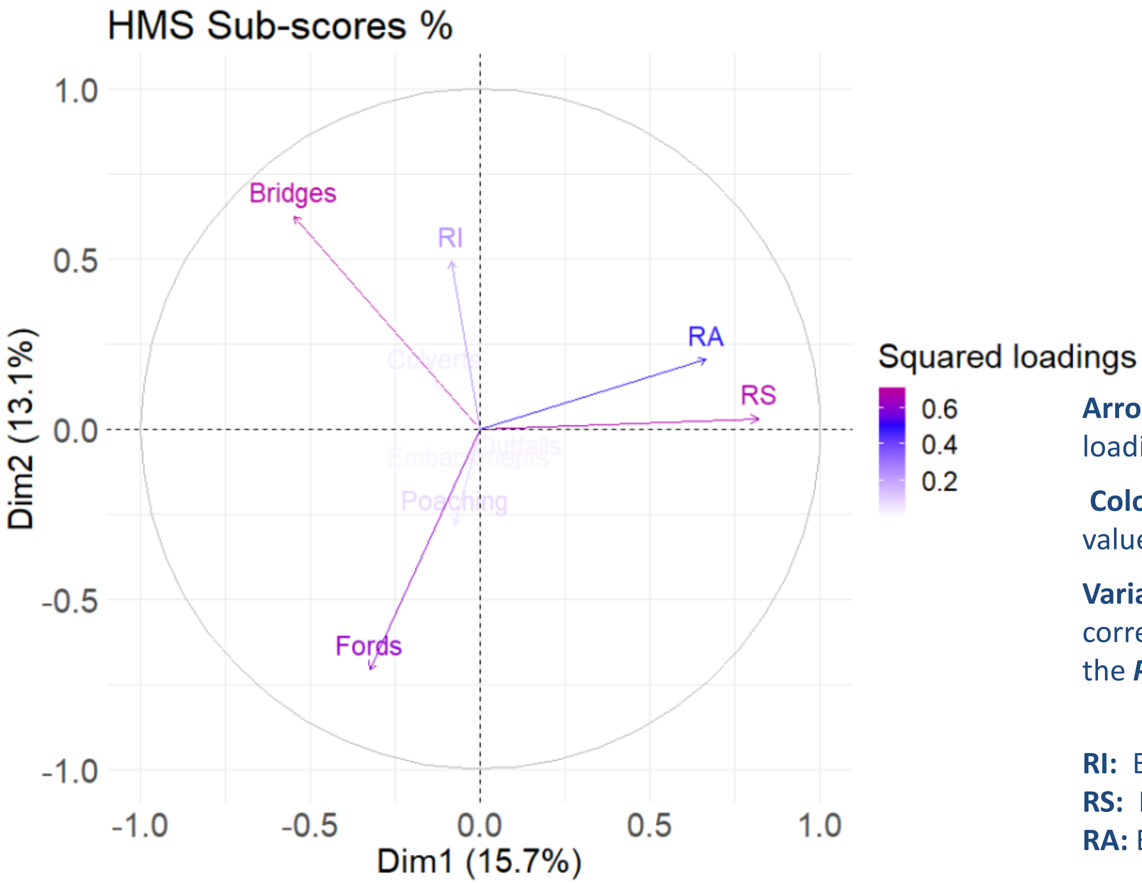
a) to assess the severity of the total ***artificial modification*** &

b) to highlight the most common & severe causes of ***longitudinal*** & ***cross-sectional*** alterations.



Source: *Stefanidis et al*. **2019, 2020**

River Reach Scale:
PCA factor map of the HMS sub-scores



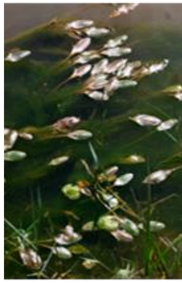
Arrows represent the squared loadings of the variables.

Color intensity is proportional to the value of the loading.

Variables that are closer to the correlation circle contribute more to the ***Principal Components***.

RI: Bank Reinforcement,
RS: Banks & Bed Re-sectioning,
RA: Banks & Bed Realignment

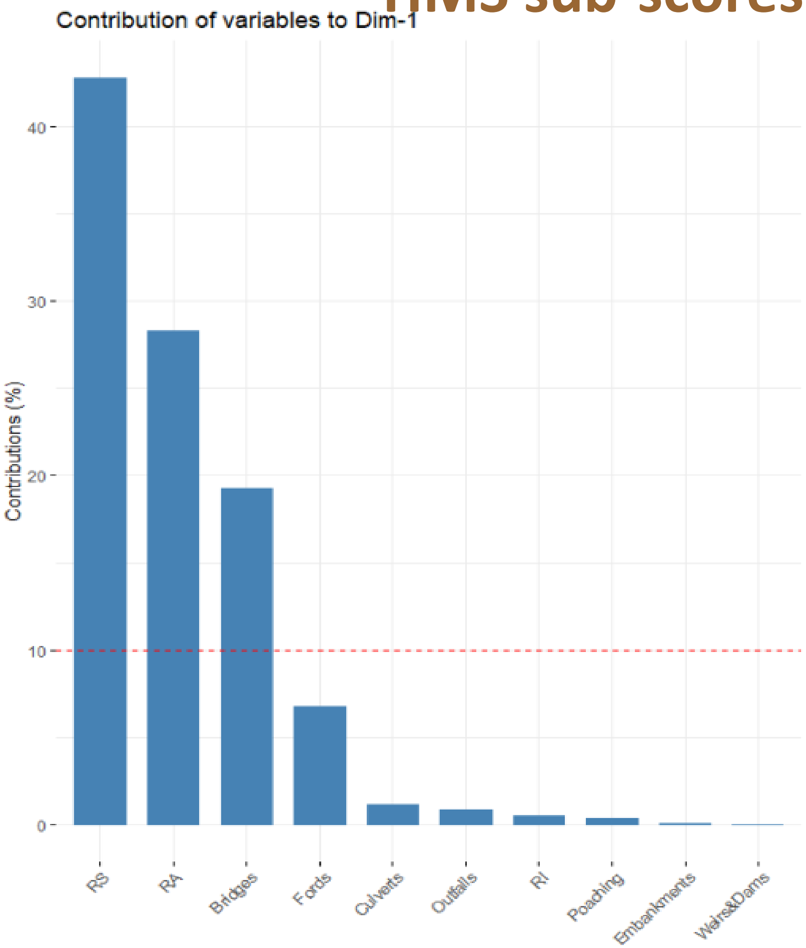


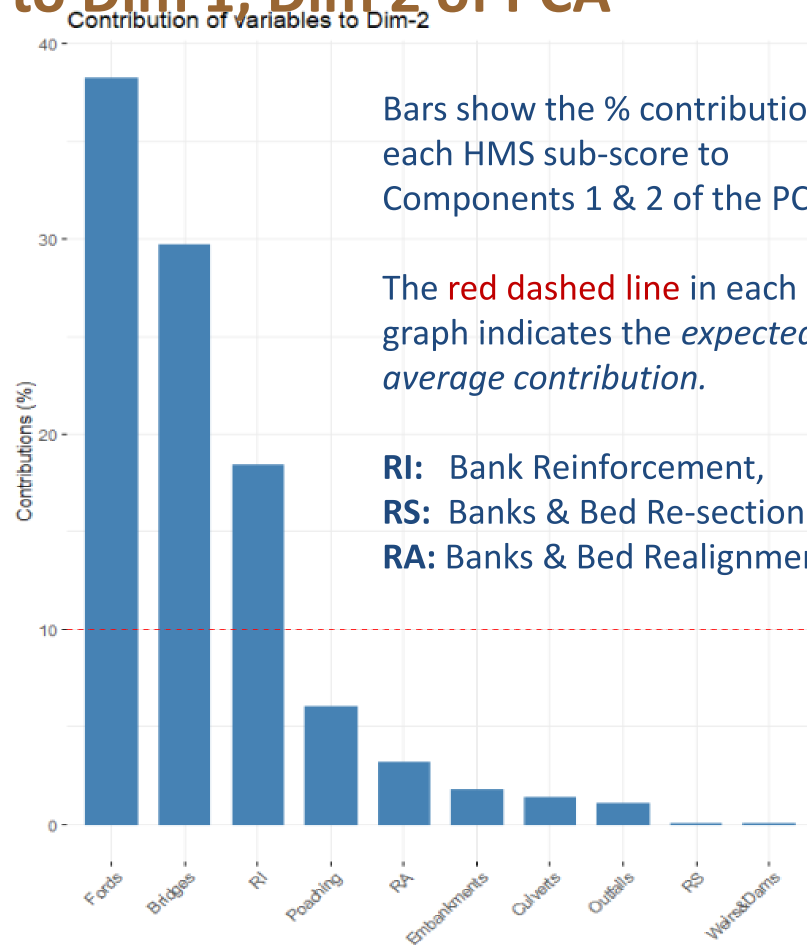


PCA results show that the presence of ***Fords***, the ***Banks & Bed Re-sectioning***, the ***channel Realignment*** & the presence of **Bridges** had the largest contribution to the first **2 P**rincipal **C**omponents.

Source: *Stefanidis et al*. **2019, 2020**

River Reach Scale:
HMS sub-scores to Dim 1, Dim 2 of PCA

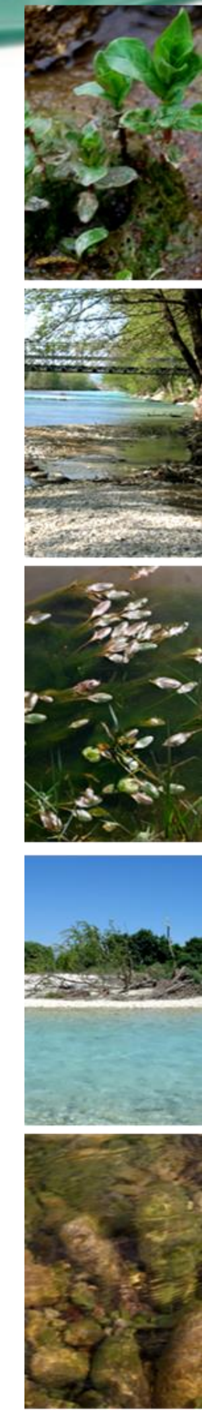




Bars show the % contribution of each HMS sub-score to Components 1 & 2 of the PCA.

The red dashed line in each graph indicates the *expected average contribution.*

RI: Bank Reinforcement,
RS: Banks & Bed Re-sectioning,
RA: Banks & Bed Realignment

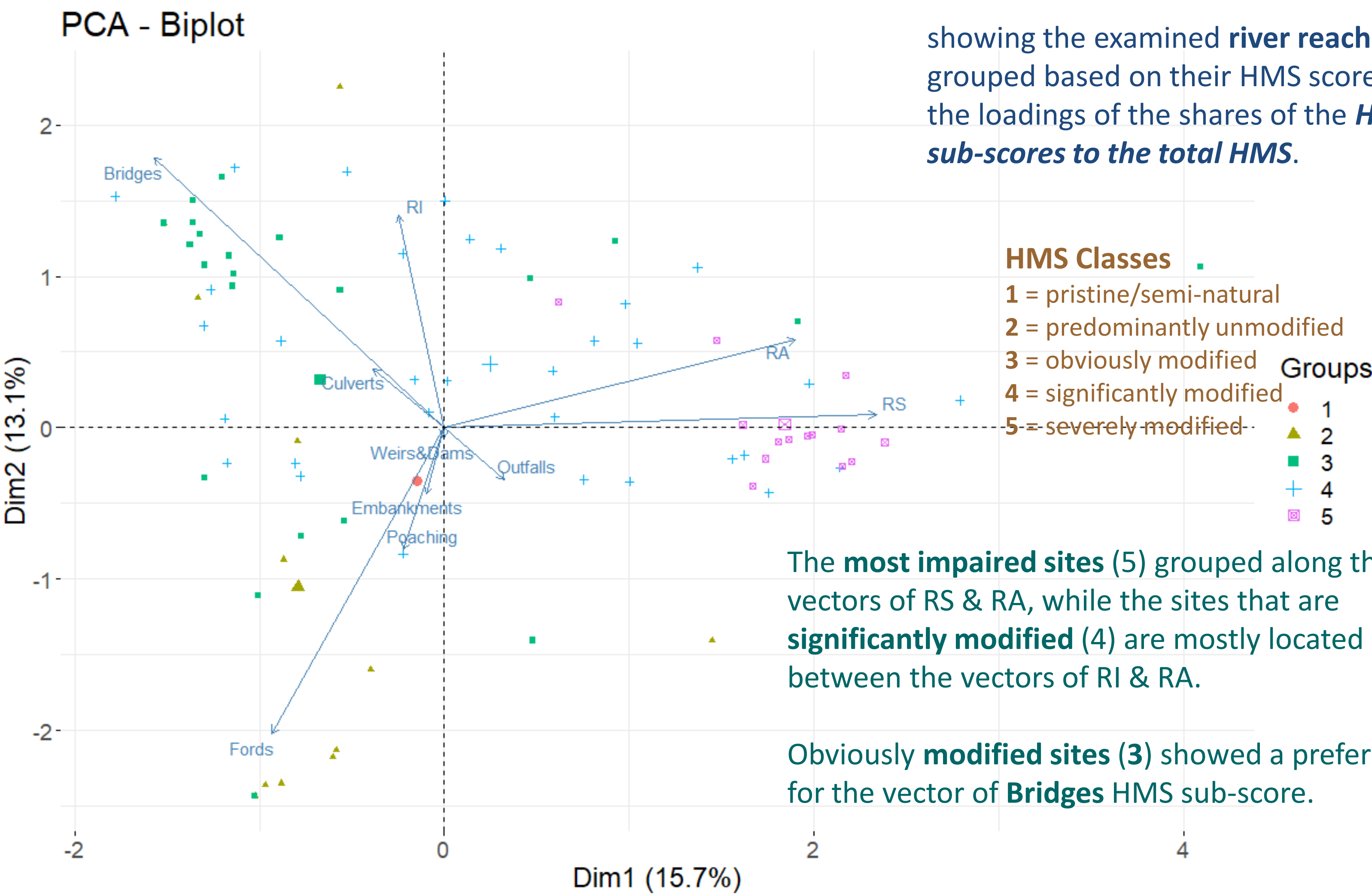


Bank & **Bed Re-sectioning**, channel **Realignment** (common *flood protection measures*) contributed the most to Component **1**. [Longitudinal Changes]

Bridges, Fords had the largest contribution to Component **2**.
[Cross-Sectional Changes]

Source: *Stefanidis et al*. **2019, 2020**

River Reach Scale: PCA Biplot - HMS sub-scores



showing the examined **river reaches** grouped based on their HMS score & the loadings of the shares of the ***HMS sub-scores to the total HMS***.

HMS Classes

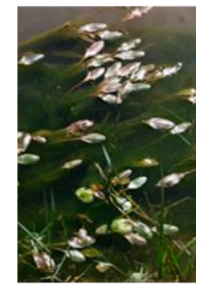
1 = pristine/semi-natural
2 = predominantly unmodified
3 = obviously modified
4 = significantly modified
5 = severely modified

The **most impaired sites** (5) grouped along the vectors of RS & RA, while the sites that are **significantly modified** (4) are mostly located between the vectors of RI & RA.

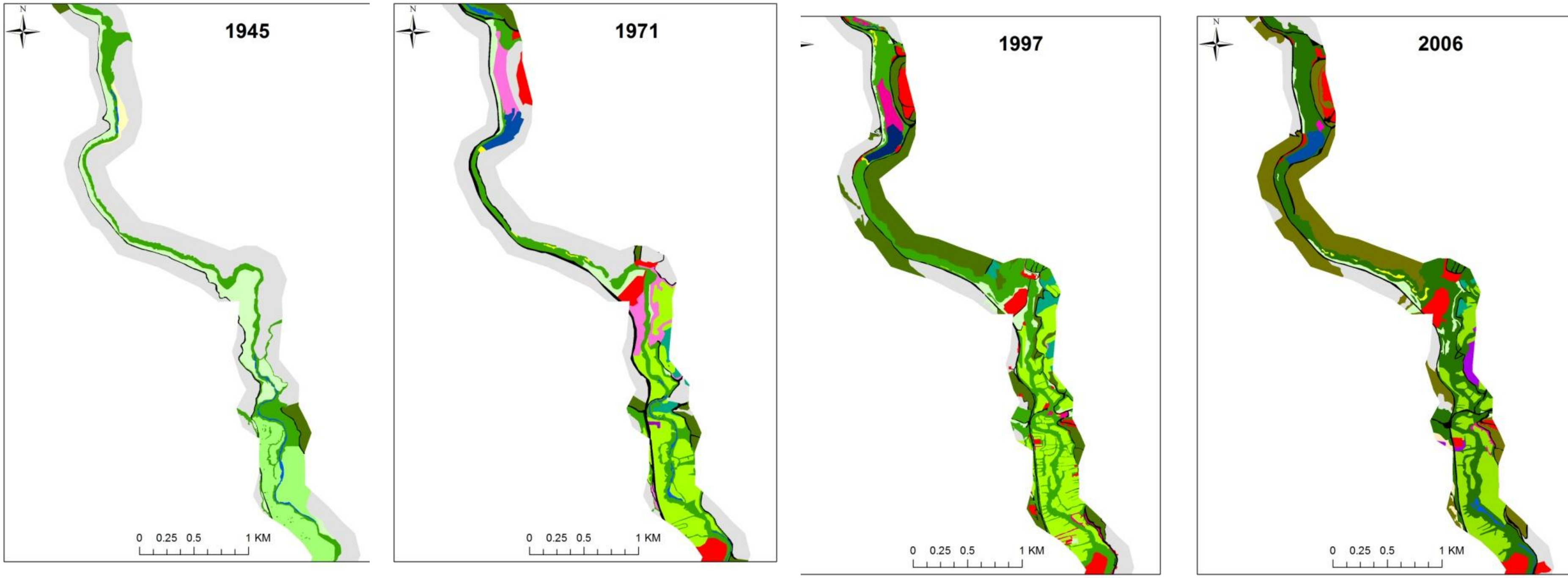
Obviously **modified sites** (**3**) showed a preference for the vector of **Bridges** HMS sub-score.

These observations imply that **Bank** & **Bed** Re-sectioning, **Realignment** are closely related with the ***severe modifications***, while at *moderately impaired river* reaches **Bridges** appear to be the dominant cause for *hydromorphological alteration*.

Source: *Stefanidis et al*. **2019, 2020**



River Segment Scale: Riparian Zone (200m) of Louros middle courses



- Urban Fabric
- Road
- Non irrigated arable land
- Permanently irrigated land
- Fruit trees
- Olive groves
- Broad-leaved forest
- Coniferous forest
- Sclerophylous vegetation
- Beaches, dunes and sand plains
- Sparsely vegetated areas
- Inland marshes
- Salt marshes
- Water courses
- Water bodies
- Coastal lagoons

Regional transformations & Land Use changes

-Significant parts of ***Riparian forests*** & ***wetlands*** transformed into ***cultivated areas***.

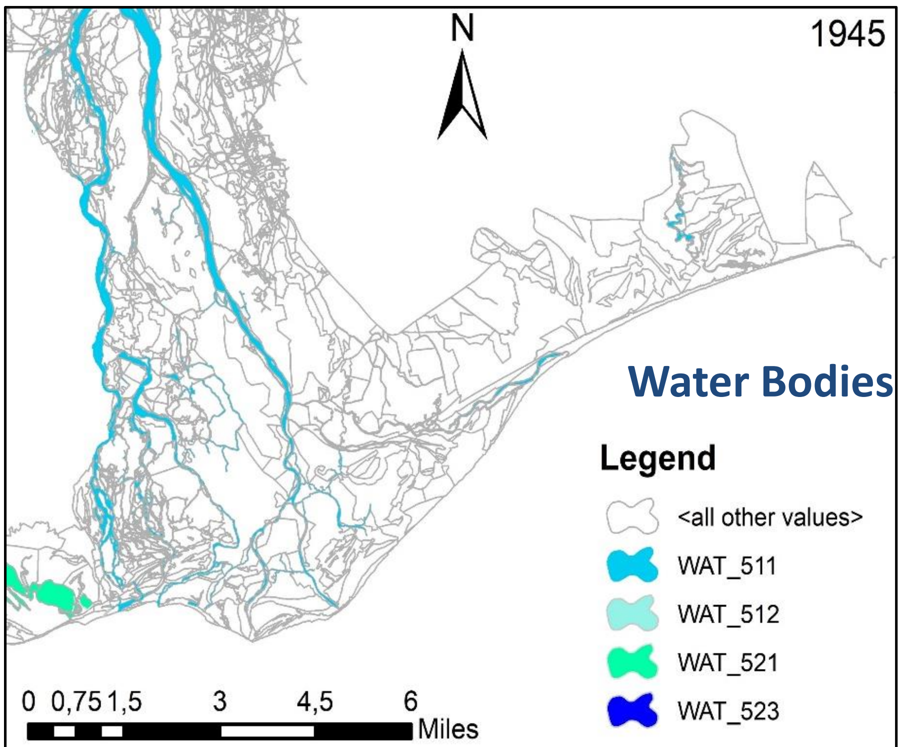
-*Hydromorphological* alterations e.g. embankments & stabilisation of the ***river banks*** resulted in the delivery of significant areas to ***Agriculture*** & *Artificial surfaces* .

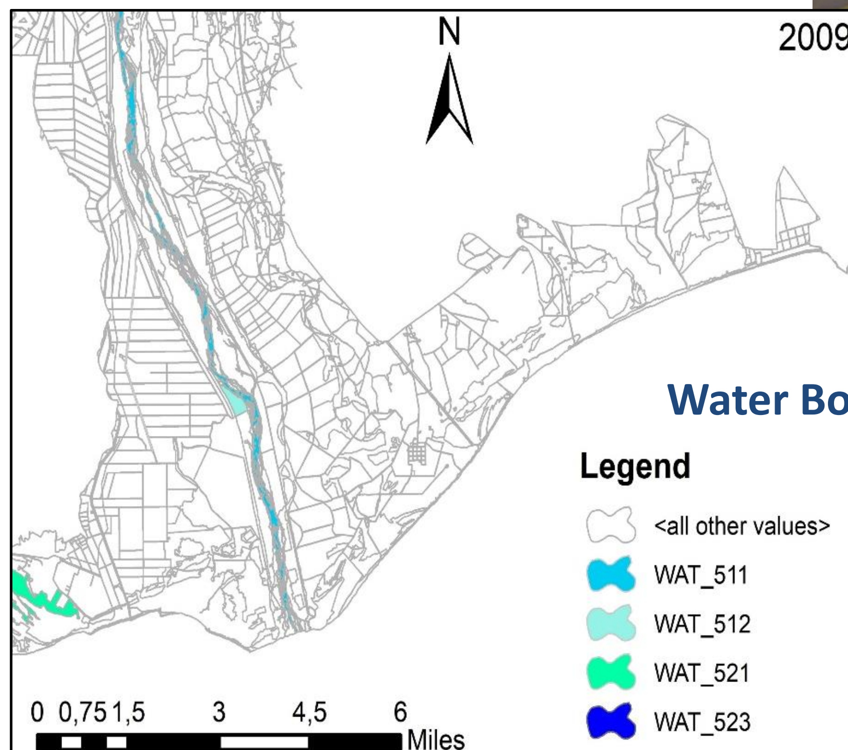
Source: *Kostara et al*. **2019, 2020**

River Catchment Scale: Nestos River lower courses - estuaries

Bank Re-sectioning is usually associated with **channel realignment** & is used for producing *more uniform channel forms* that facilitate ***flood flows***.

Thus, ***bank*** *&* ***channel Re-sectioning*** involves modifications that are part of *flood defense management practices* that usually protect neighboring **agricultures** from ***flood*** *events*.



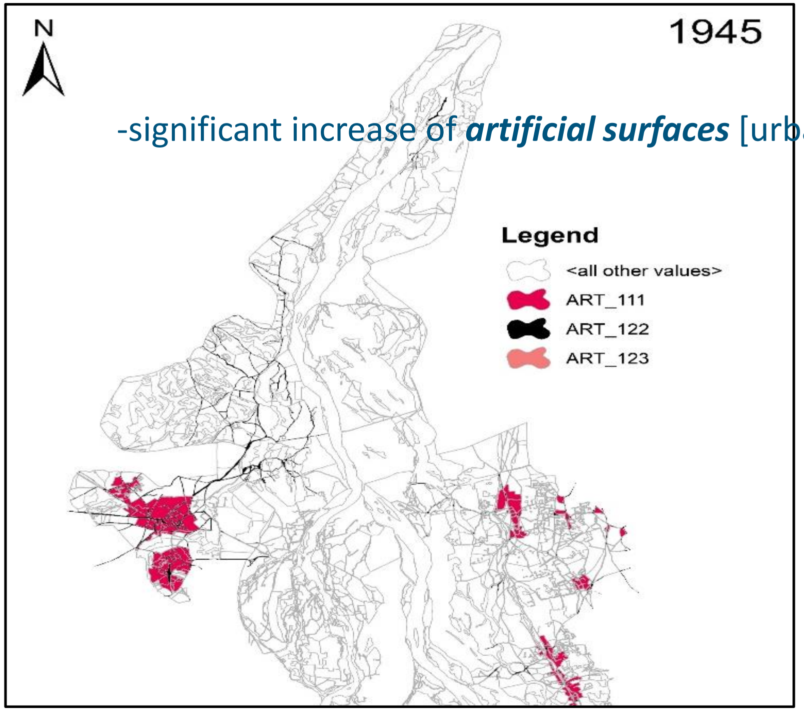


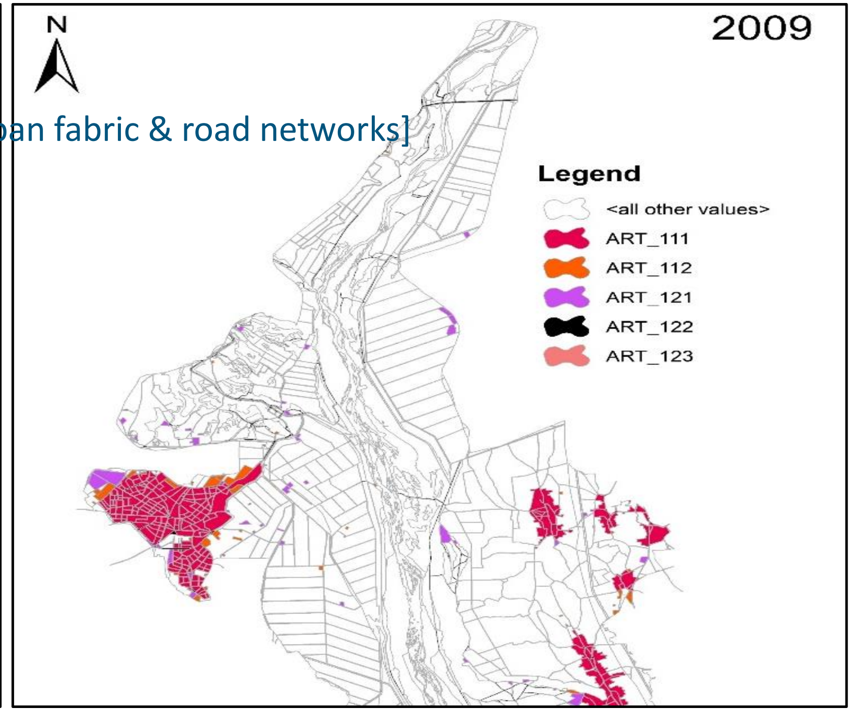
Source: *Chroni et al*. **2019, 2020** (submitted)

River Catchment Scale: Nestos River lower courses

Urban areas

-significant increase of ***artificial surfaces*** [urban fabric & road networks]





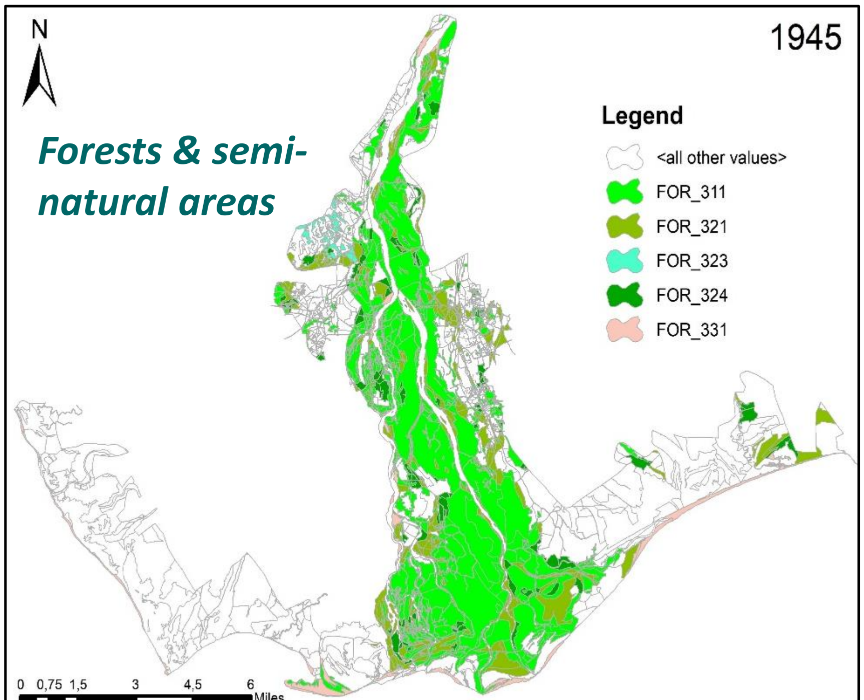
Source: *Chroni et al*. **2019, 2020** (submitted)

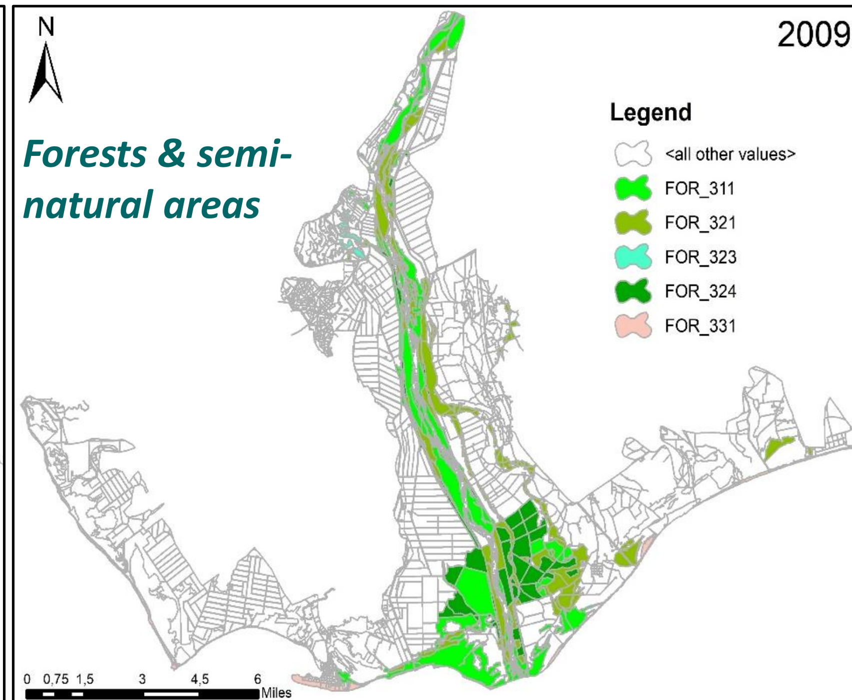
River Catchment Scale: Nestos River

Stabilisation of the ***river banks*** & ***embankments*** have resulted in the delivery of significant areas to **agriculture**.

Significant parts of the extended ancient ***Riparian forest*** *of Nestos* & ***wetland areas*** were transformed to the less natural land covers.

LANDCOVER CODE	Class	LCLU	NATURA 2000 Code	N. C. %
Forests & semi-natural areas (FOR)	3.1.1	Broad-leaved forest	91F0, 92A0, 91M0, 92D0 και 91E0	**-53.75**
	3.2.1	Natural grassland	62A0, 6290 και 6420	-15.54
	2.3.1	Pastures	62A0, 6290 και 6420	-57.59
	3.2.3	Sclerophylous vegetation	5350	**-38.28**
	3.2.4	Transitional woodland shrub (Reforestation)		**24.63**
	3.3.1	Beaches, dunes & sand plains	1210, 2110, 2120, 2190 και 2220	-35.81

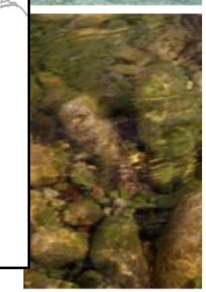




Source: *Chroni et al*. **2019, 2020** (submitted)

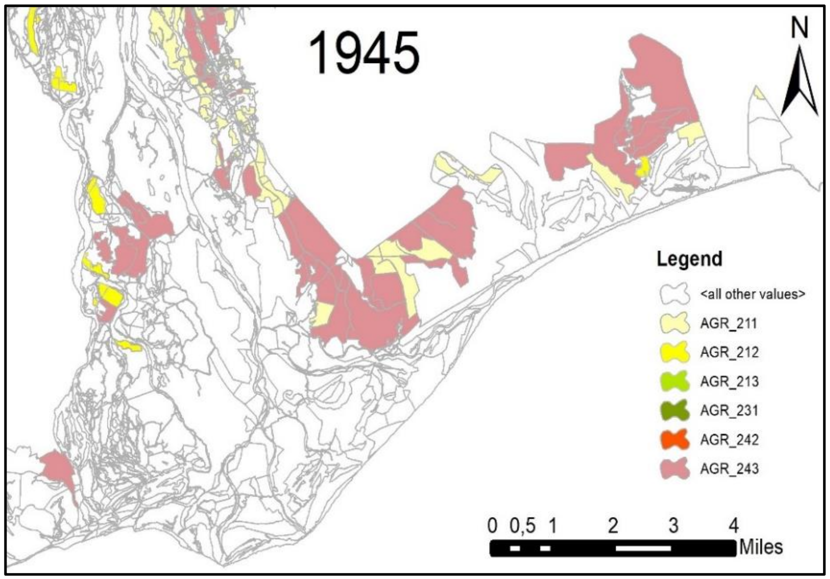


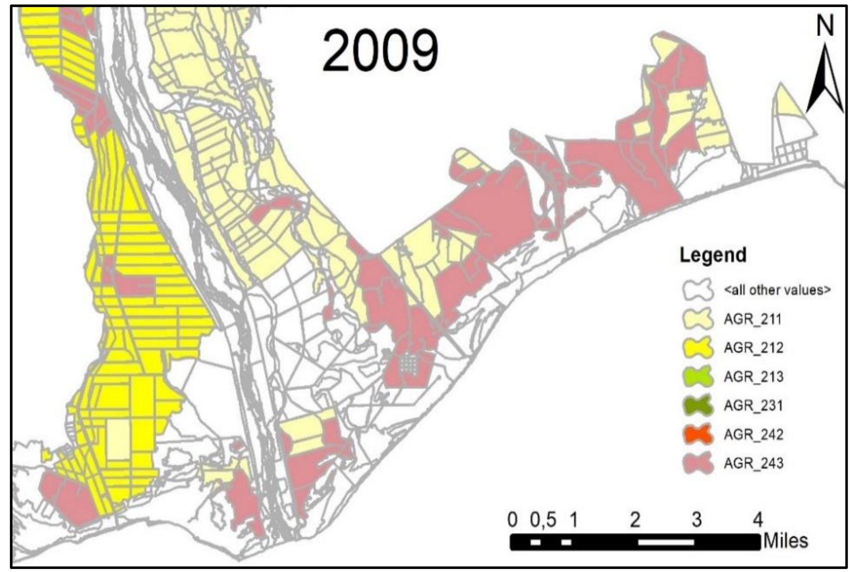




River Catchment Scale: Case Study Nestos River

Agricultural areas

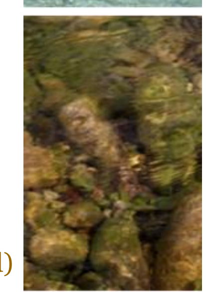




- significant increase of the total area of ***agricultural land*** [rice, cropland, cotton, corn, etc.]

2.1.1	Non irrigated arable land
2.1.2	Permanently irrigated land
2.1.3	Rice fields
2.3.1	Pastures
2.4.2	Complex Cultivations
2.4.3	Abandoned agricultures

Source: *Chroni et al*. **2019, 2020** (submitted)



Multiple facets of riparian plant diversity in Mediterranean rivers





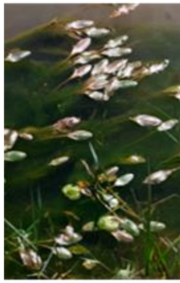
Objectives/Questions: What ***drives riparian diversity*** in river corridors?

- Patterns of species richness (**a-diversity**) along environmental gradients
- Environmental filters or geographic factors shape communities (*examine* ***b-diversity patterns***)

- ***Riparian plants & aquatic vegetation*** were assessed in the same river network of more than **100 river reaches**
- ***Community composition*** & *cover abundance were* recorded along **100 m** in both banks & channel
- ***Environmental*** variables were measured (water chemistry) & calculated (**HMS** & ***Channel alteration)***

Source: *Stefanidis et al*. **2020** in preparation

Multiple facets of riparian plant diversity in Mediterranean rivers



- **a- diversity** were assessed for each reach (***Species Richness*** & ***Shannon-Wiener H***) [R -packages "vegan" & "FD"]

- **Functional diversity indices** were calculated: Functional richness (Fric), Functional evenness (Feve), Functional divergence (Fdiv), Functional dispersion (Fdis) Rao's quadratic entropy (RaoQ) [R- function *dbFD]*

- **Taxonomic diversity** *Delta* were calculated accounting for **5** taxonomic levels [functions *taxondive* & *taxon2dist]*

- Relationships between ***diversity indices*** & ***environmental variables*** were examined [Fit Generalized Additive Models, package "mgcv" R)

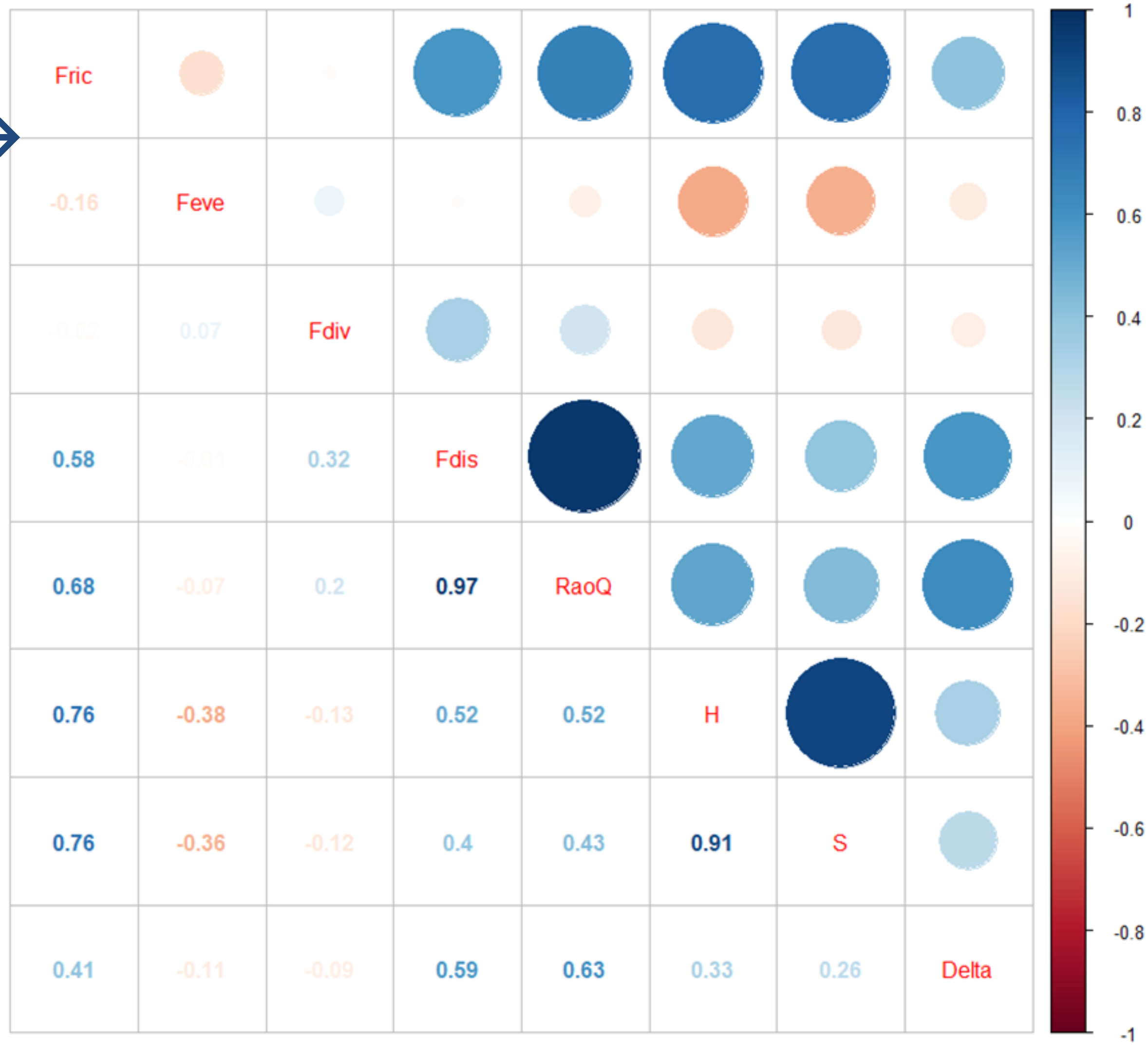
- Focus on **patterns of diversity** along ***gradients*** of *hydromorphologic change*

Preliminary results

Evidence for ***High correlation*** between **Species Richness** & **Functional Richness** →

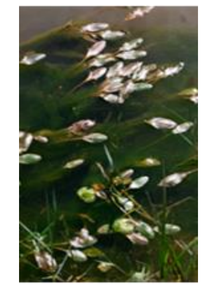
similar finding for macrophytes in watersheds of China (Zhang et al. 2019) & macroinvertebrates in Finland (Heino et al., 2008)

Low correlation between ***Taxonomic diversity,*** *Species Richness & Functional Richness*

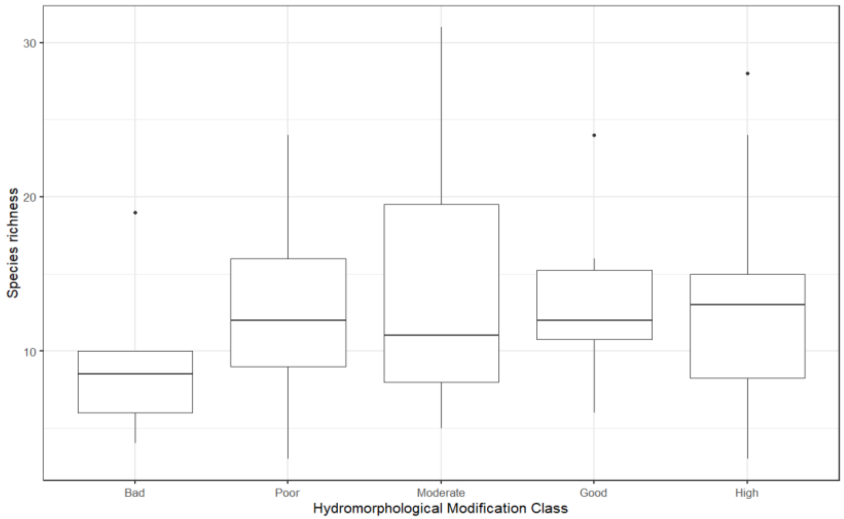


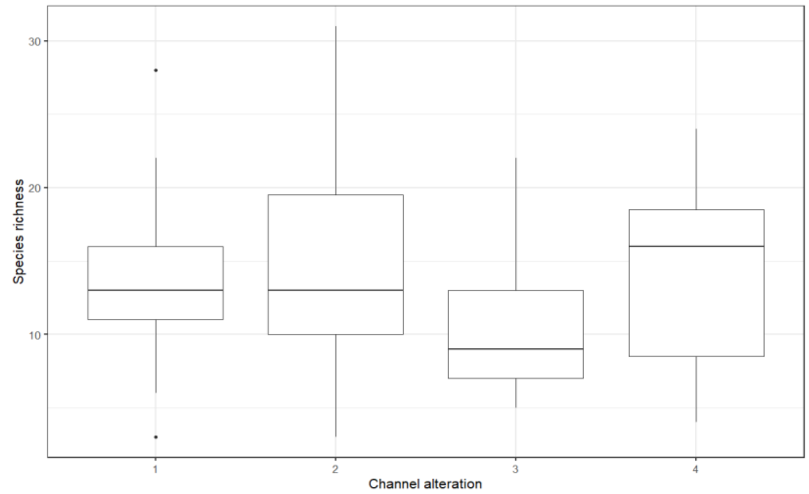
Source: *Stefanidis et al*. **2020** in preparation

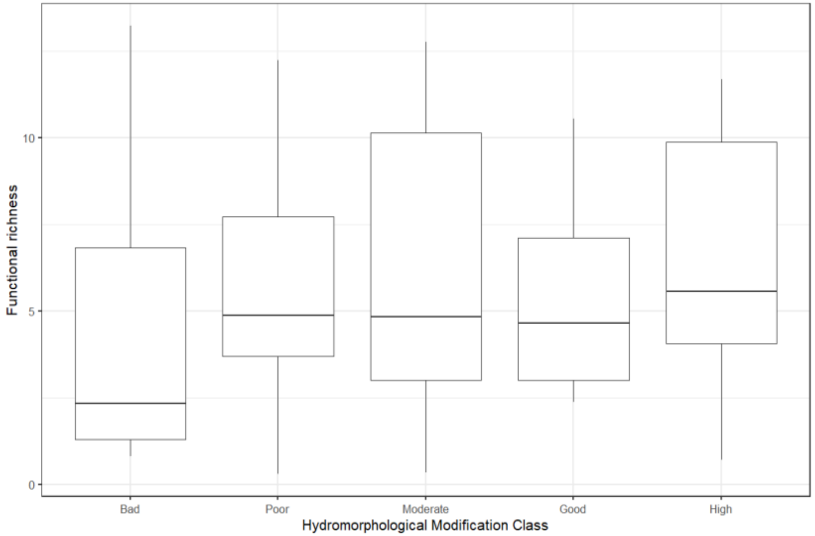


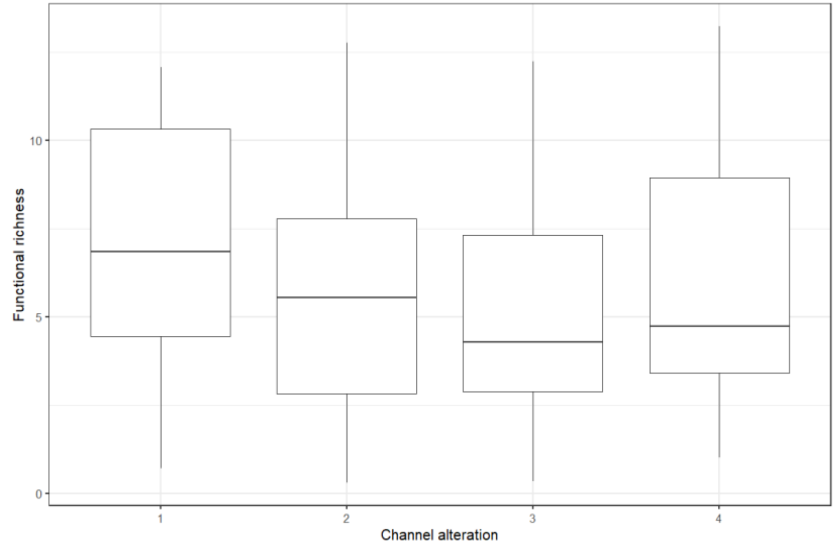


HMS, Channel alteration & *diversity indices*







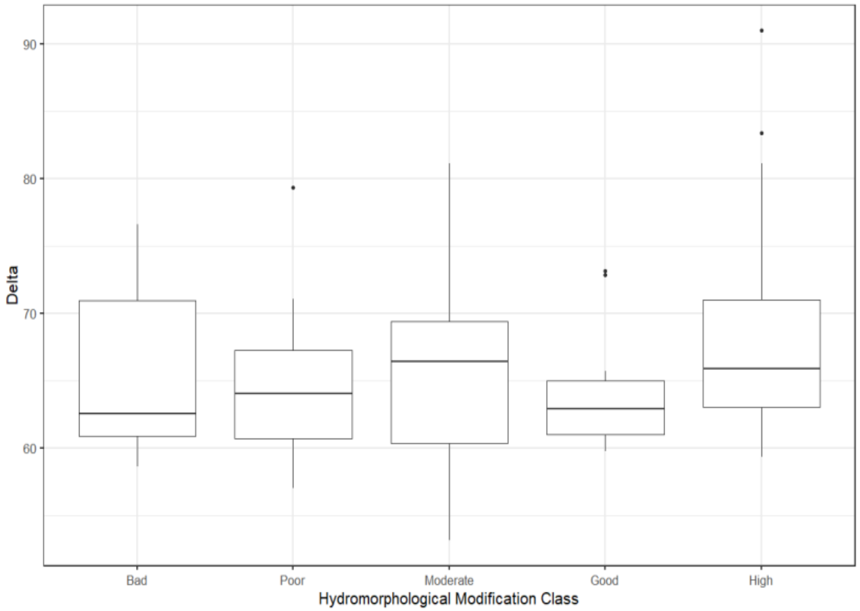


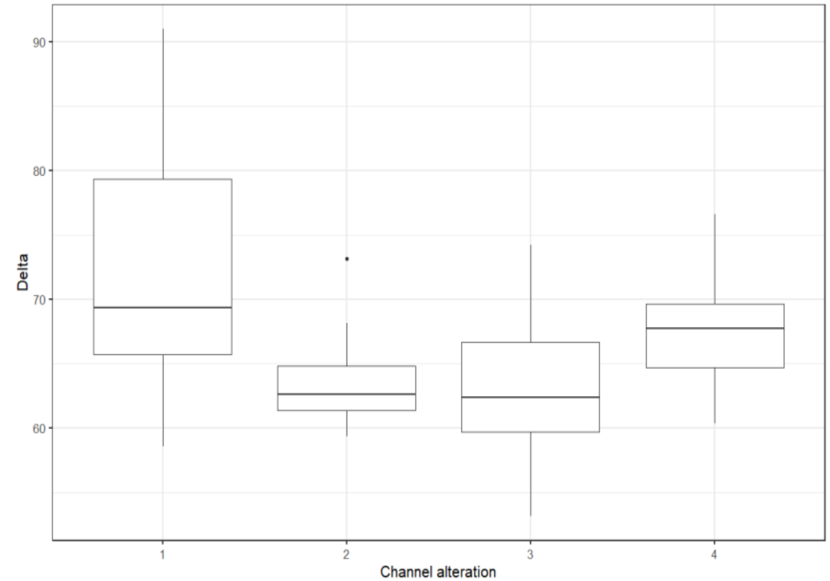




Functional & **species richness** were lower in “***Heavily modified***” reaches (*but not significant difference*)

HMS, Channel alteration & *diversity indices*





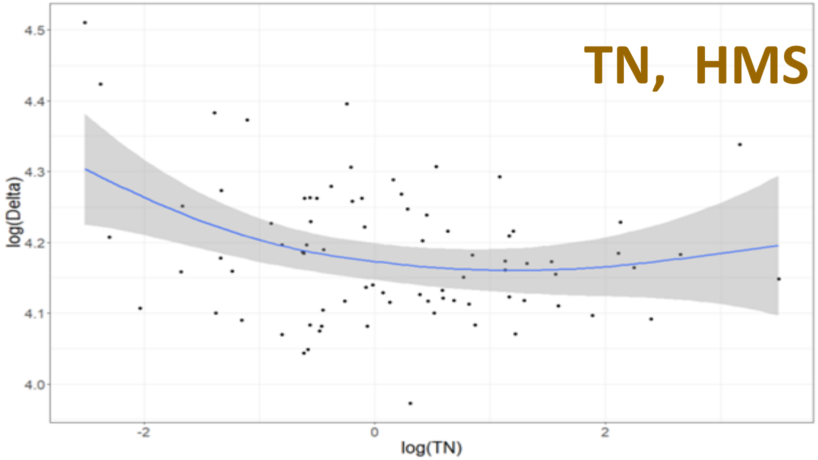
Taxonomic diversity significantly *higher* in reaches with ***low channel alteration***

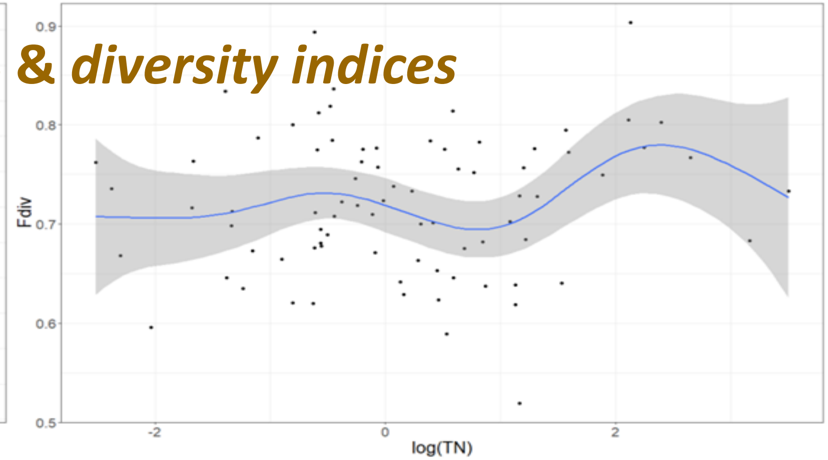
Source: *Stefanidis et al*. **2020** in preparation

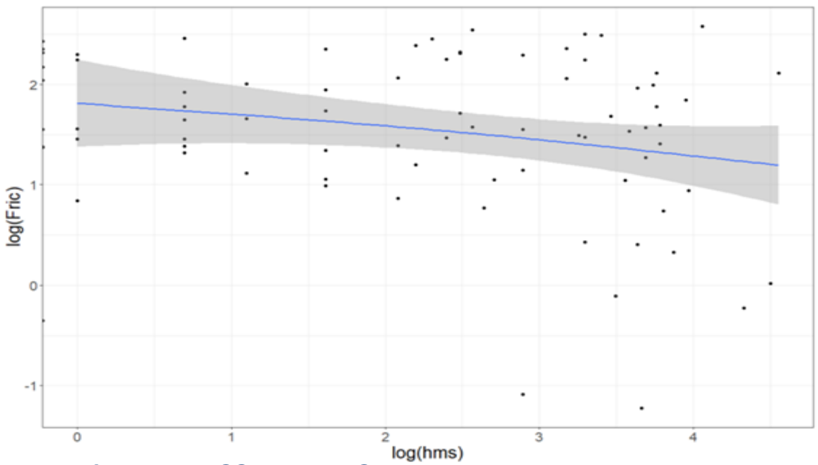


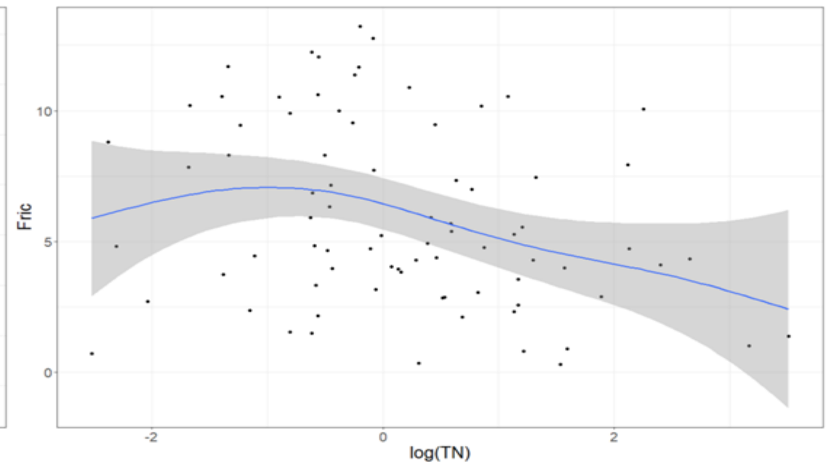


TN, HMS & *diversity indices*



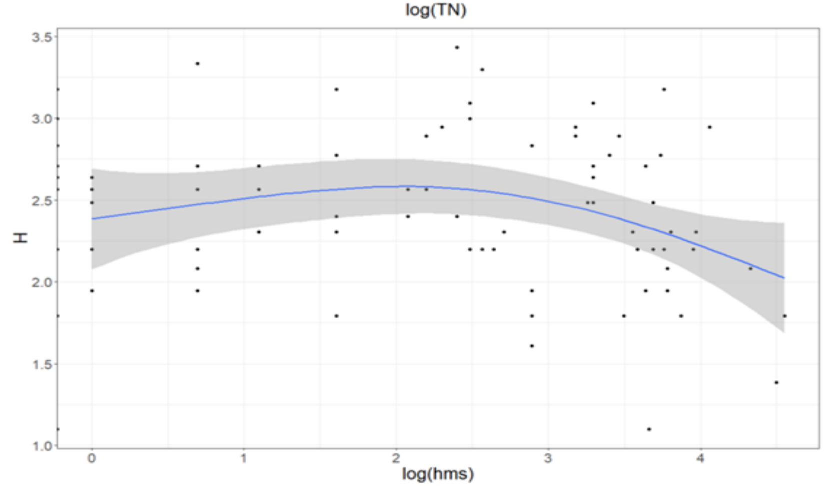






Explore effect of **TN** & **H**ydromorphological **M**odification **S**core on various ***diversity indices***

HMS & **TN** have a <u>*negative effect*</u> on ***species richness*** & ***functional richness***



Next steps:

- Examine b-diversity patterns along environmental and spatial patterns

- Investigate for patterns for separate plant groups (e.g. hydrophytes, helophytes, woody riparian vegetation etc.)

- Combine community data with spatial data on pressures (e.g. land uses in riparian buffers)






Thank you for your attention


Thank you for your attention

GIS spatial geo-database- CORINE land cover Classification System

Level 1	Level 2	Level 3	Abbrev.	
1. Artificial surfaces	1.1 Urban	1.1.1 Urban Fabric	AUU	Artificial surfaces
	1.2 Industrial, commercial and transport units	1.2.2 Road and rail networks & associated land	AIR	
2. Agricultural areas	2.1 Arable land	2.1.1 Non irrigated arable land	AAN	Cultivations
		2.1.2 Permanently irrigated land	AAP	
	2.2 Permanent crops	2.2.2 Fruit trees	APF	
		2.2.3 Olive groves	APO	
	2.4 Heterogeneous agricultural areas	2.4.4 Agro forestry areas	AHF	
3. Forests & semi natural areas	3.1 Forests	3.1.1 Broad-leaved forest	FFB	Natural Land
		3.1.2 Coniferous forest	FFC	
	3.2 Shrub / herbaceous vegetation associations	3.2.1 Natural grassland	FSN	
		3.2.3 Sclerophylous vegetation	FSS	
	3.3 Open spaces with little or no vegetation	3.3.1 Beaches, dunes & sand plains	FOB	Bare Land
		3.3.3 Sparsely vegetated areas	FOS	
4. Wetlands	4.1 Inland wetlands	4.1.1 Inland marshes	WIM	Wetlands
	4.2 Coastal wetlands	4.2.1 Salt marshes	WCM	
5. Water bodies	5.1 Inland waters	5.1.1 Water courses	WIC	Water
		5.1.2 Water bodies	WIB	
	5.2 Marine waters	5.2.1 Coastal lagoons	WME