Riparian vegetation: Knowledge conversion for understanding river functioning and status

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COST CONVERGES (Action CA16208) Madrid, Spain, 10 July 2018

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OUTLINE

I. RIPARIAN ZONES: Human-disturbed ecosystems

II. MULTIPLE WAYS for KNOWLEDGE ACHIEVEMENT – 15y of case studies in Portugal: Landscape level [Remote sensing tools] & Local Level [Functional diversity approaches]

III. KNOWLEDGE CONVERSION - 10 THOUGHTS

RIPARIAN ZONES- DYNAMIC ECOSYSTEMS

hot-spots of biodiversity, refuge, habitat, visiting, dispersal corridors, linear oasis, shade, leaf litter, woody debris, buffer zone, trophic webs, naturally resilient,…

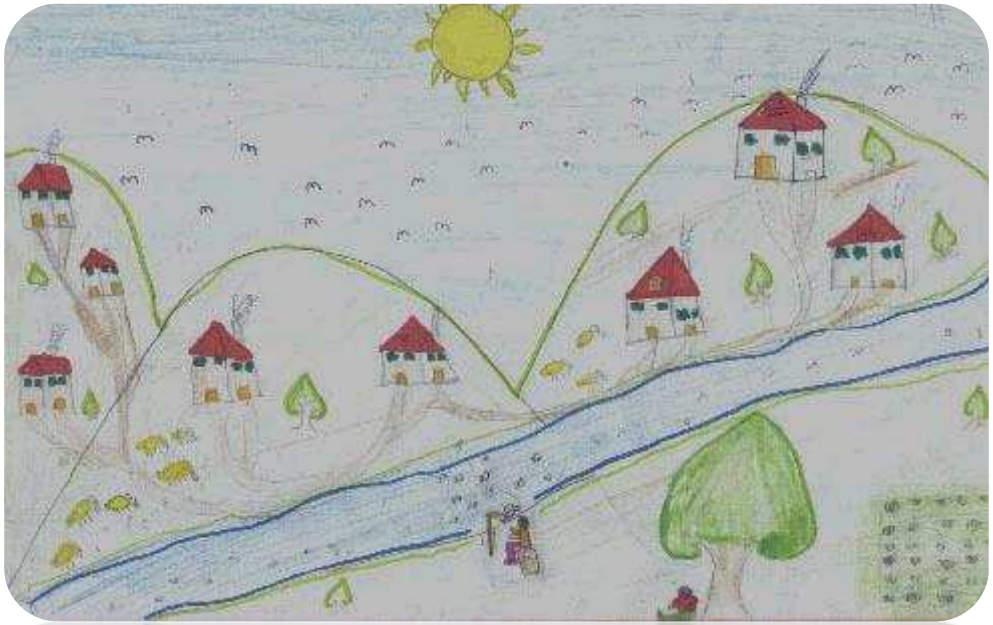
I. RIPARIAN VEGETATION - HUMAN-DISTURBED ECOSYSTEMS

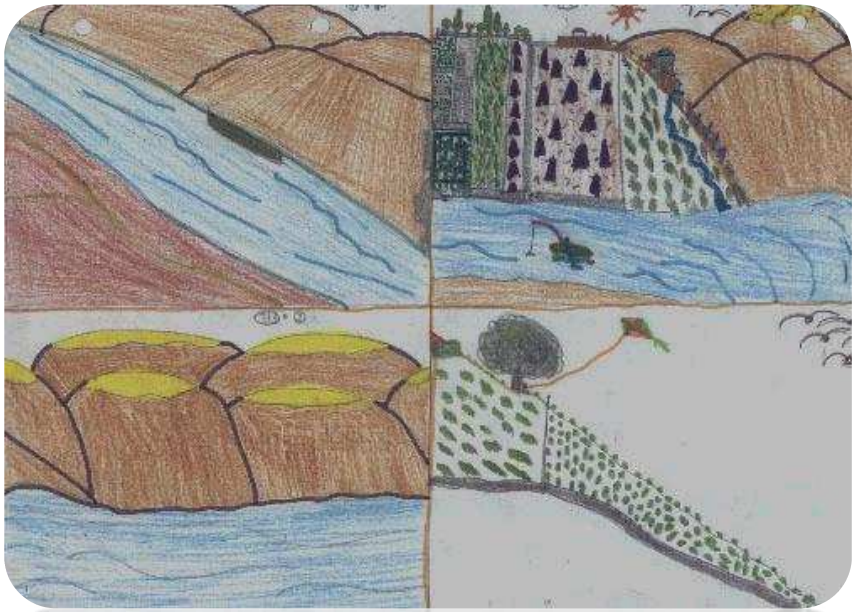
narrow, fragile, constrained, invaded, fragmented, human-disturbed, low woody species richness, altered recruitment

World Heritage Oporto Wine Region, North Portugal, River Douro

Irrigation crops (SW Portugal), River Sado

CHALLENGE - HELP TO CHANGE THESE VIEWS…





LIVING IN A FRAGMENTED WORLD

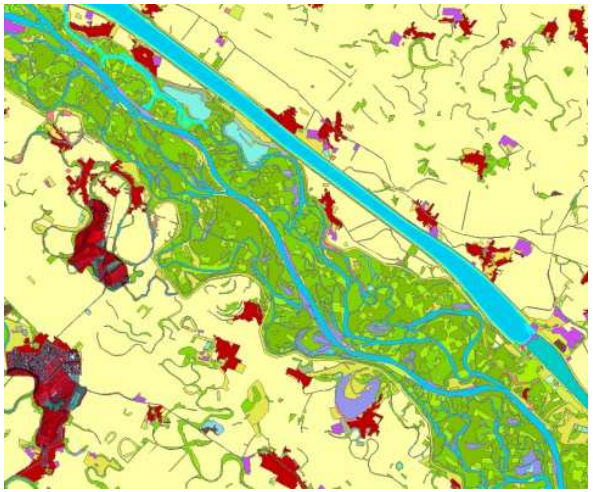
Rivers and riparian zones are fragmented....

naturally fragmented …

… and fragmented by Man.

Are they enough 'Resilient'?

Hagen et al. 2012/Adv Ecol. Res. 43: 89-210.



Credits: Copernicus Land Monitoring service
(Satellite imagery © Airbus Defence & Space, 2011, provided under EC/ESA GSC-DA).

EU is one of the most fragmented continents in the world.
30% percent of the EU land is moderately to highly fragmented (EU Biodiversity Strategy, 2011).

"WHAT DO YOU MEAN, 'RESILIENT'?"

'resistance' and 'recovery' are measurable components that together represent resilience

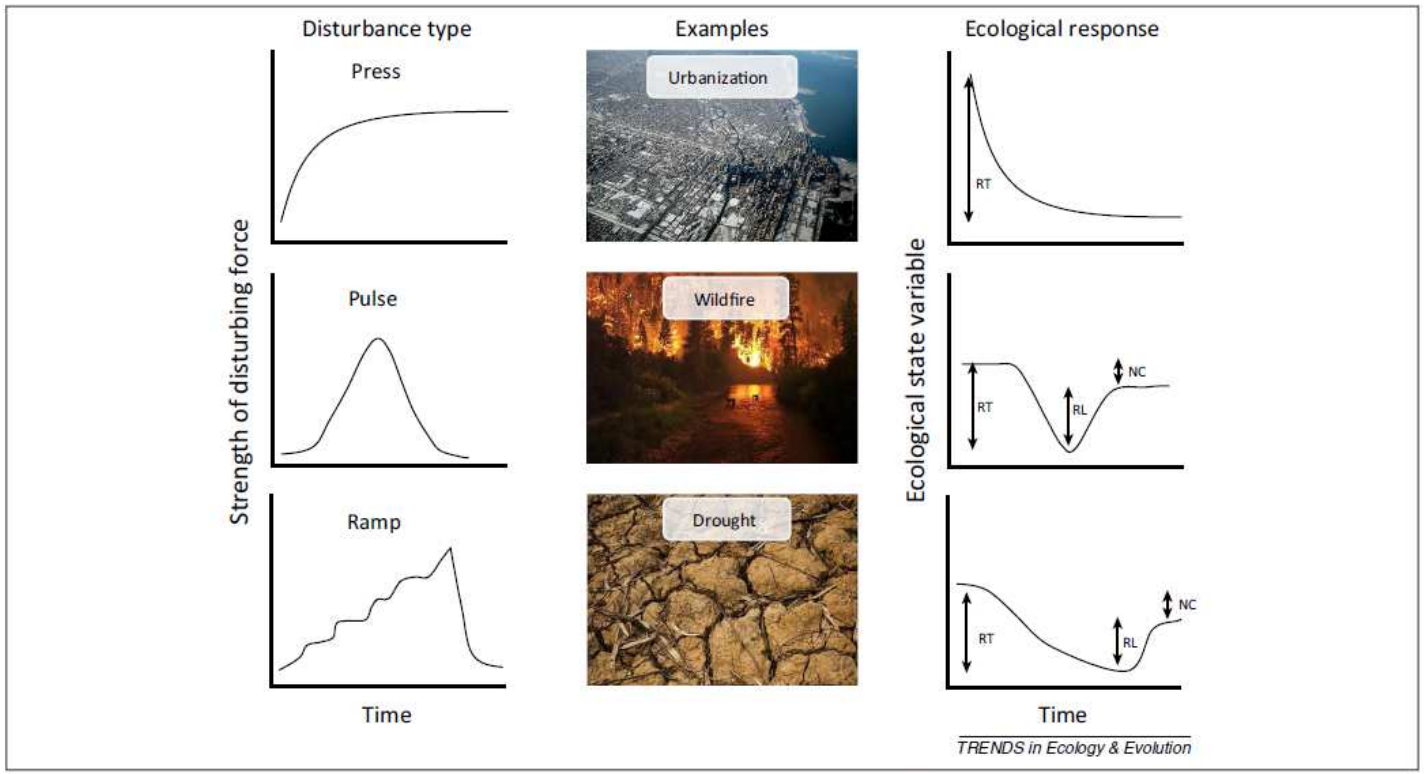


Figure 1. Types of disturbances, the ecological responses they engender, and measurement of resistance (RT), resilience (RL), and net change (NC) within the resistance–resilience framework. Modified from Lake [58]. Urbanization: Wiki commons image, license details https://commons.wikimedia.org/wiki/File:Chicago_Downtown_Aerial_View.jpg; Wildfire: Wiki commons image, license details https://commons.wikimedia.org/wiki/File:Deerfire_high_res_edit.jpg; Drought: Wiki commons image, license details https://commons.wikimedia.org/wiki/File:Cracked_ground_151.jpg.

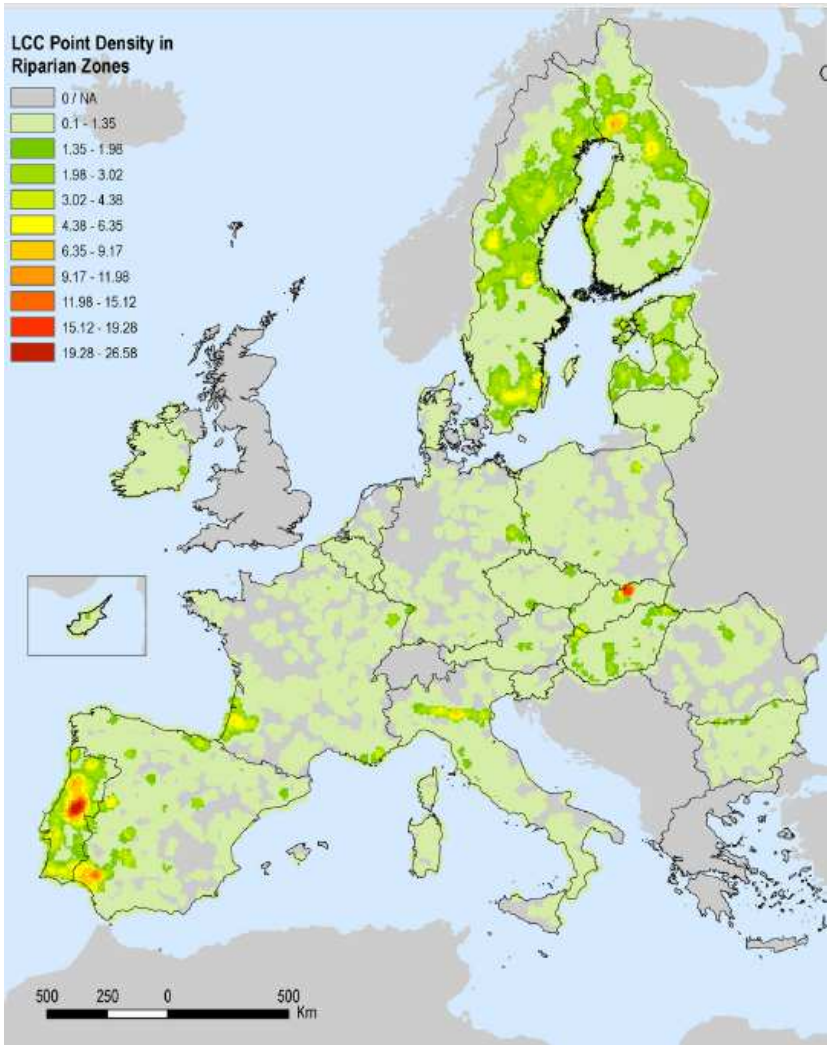
Hodgson, McDonald and Hosken 2015/ Trends in Ecology & Evolution 30: 503-506.

IBERIA: Hot-spot of Land Use and Land Cover change of European Riparian Zones

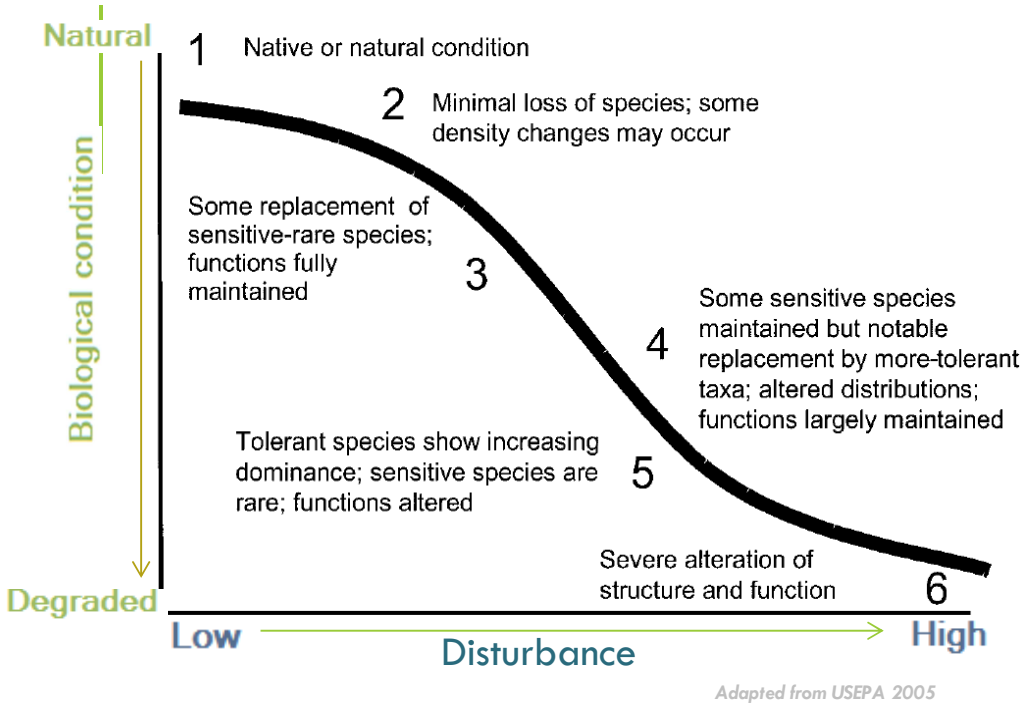
- Forestry
- Fire
- Agricultural land abandonment

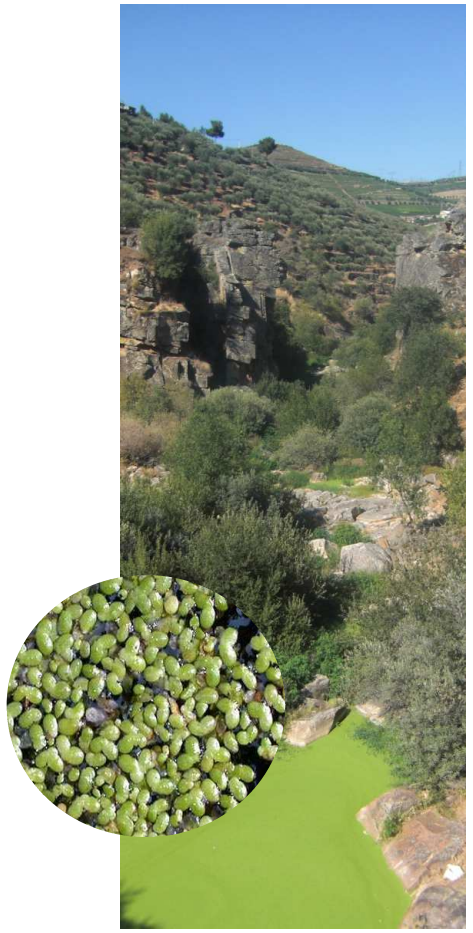
(rural exodus; immigration)

Clerici, Paracchini and Maes, 2014/ Ecohydrology & Hydrobiology 14: 107-120.



II. MULTIPLE WAYS FOR KNOWLEDGE ACHIEVEMENT – 15Y OF CASE STUDIES IN PORTUGAL

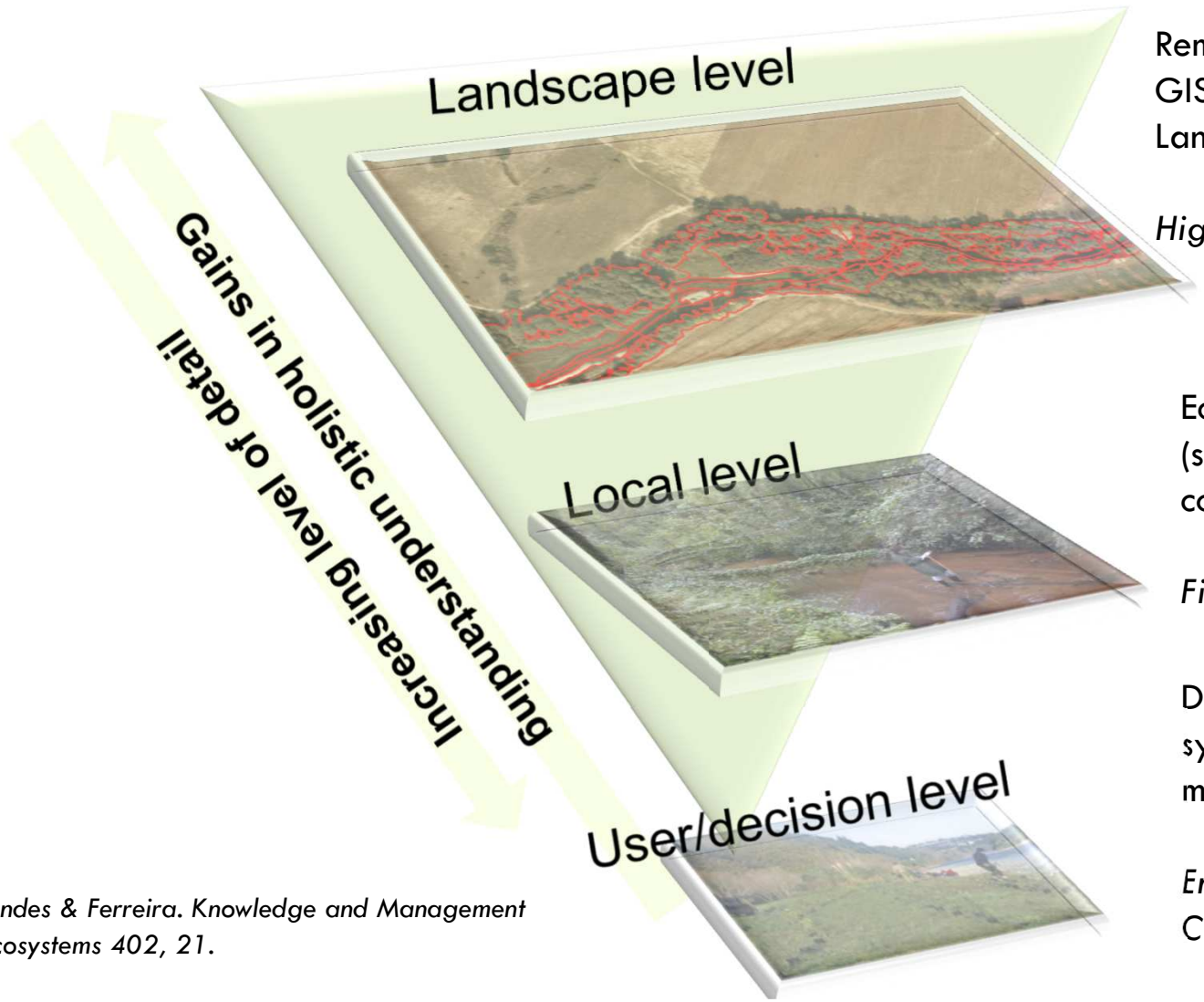




- When resources are altered, competitive hierarchies in aquatic and riparian vegetation change, whit shifts in species composition and suites of traits

Conceptual base

TOOLS & DATA



Remote sensing
GIS
Landscape metrics

High resolution imagery

Ecological indicators (structural, functional, compositional)

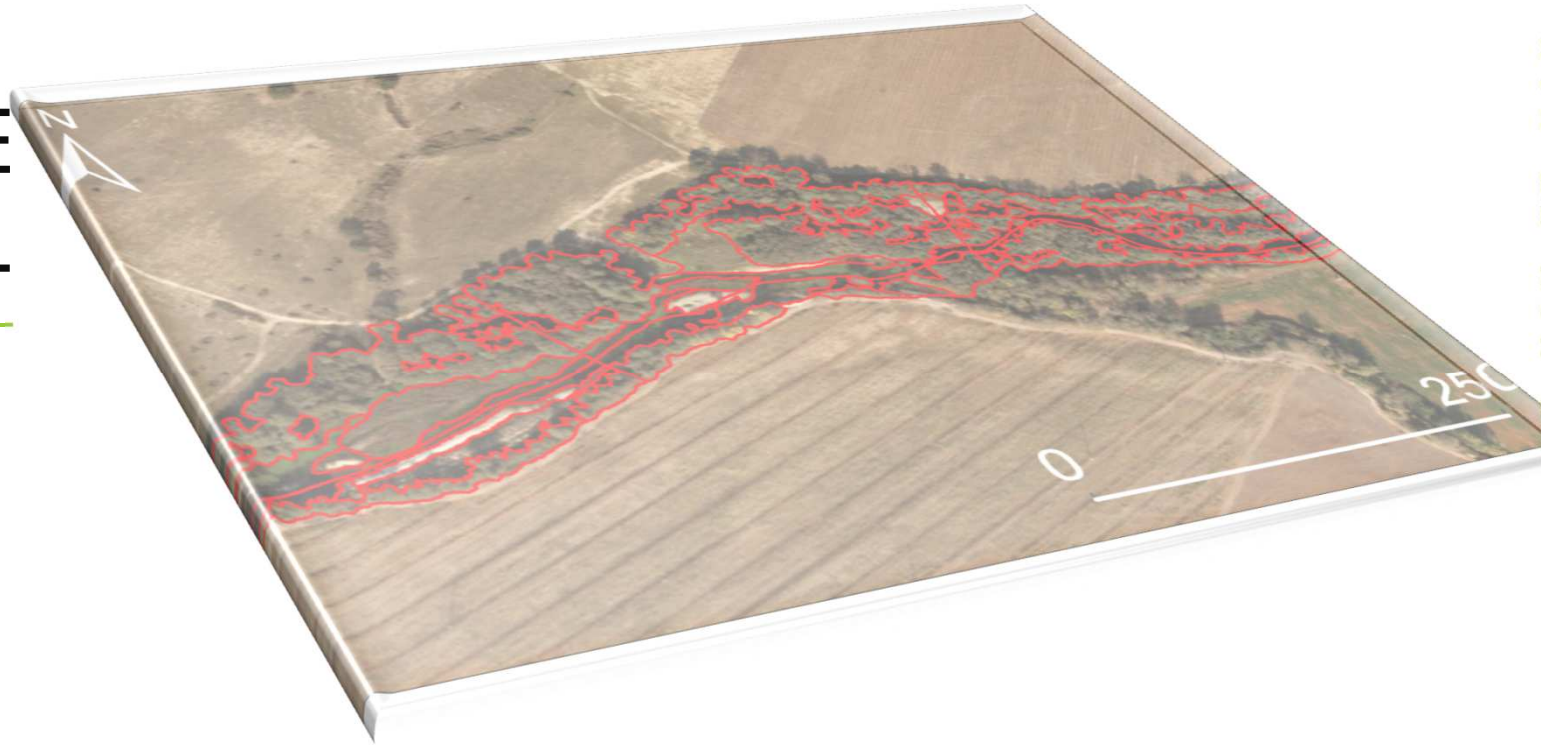
Field data

Decision support systems; multi-criteria methods, …

Environmental policy, Cost-benefits analysis,…

Aguiar, Fernandes & Ferreira. Knowledge and Management of Aquatic Ecosystems 402, 21.

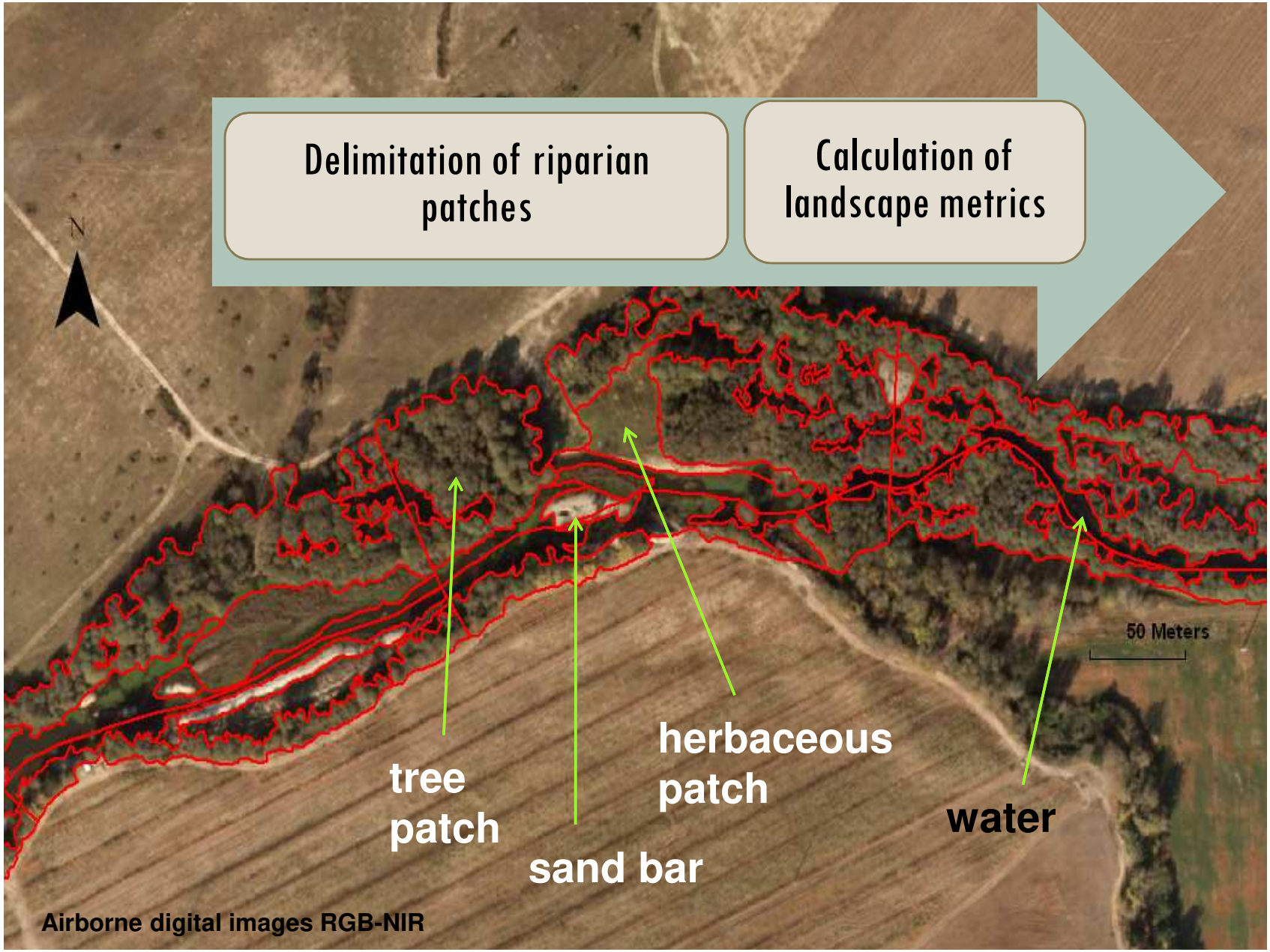
LANDSCAPE LEVEL



CASE STUDY 1

EFFECTS OF LAND USE AND LAND COVER – Tributaries of Tagus River

Fernandes, Aguiar & Ferreira 2011/ Landscape and Urban Planning 99:166-177.


Delimitation of riparian patches
Calculation of landscape metrics
N
50 Meters
tree patch
sand bar
herbaceous patch
water
Airborne digital images RGB-NIR

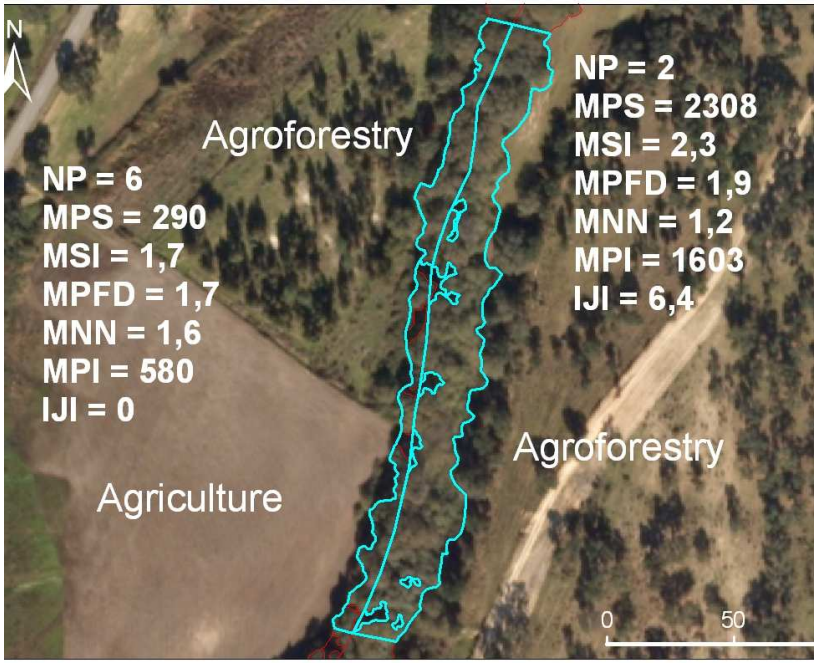
LANDSCAPE METRICS

CATEGORY	• Landscape metrics	**Proxy for riparian strutural attributes**
AREA/ DENSITY	• Number of patches (NP) • Weighted Class Area (WCA) NP*MPS/Total area of SU • Mean Patch Size (MPS) • Patch Size Coefficient of Variation (PSCov)	Area, size and structural heterogeneity
SHAPE/ EDGE	• Area Weighted Mean Patch Fractal Dimension (AWMPFD) • Edge Density (ED)	Spatial complexity and lateral connectivity

Patch Analyst (vector format) for ArcGIS 10.1

CASE STUDY – LAND USE

IT IS EXPECTED THAT DEGRADATION RESULT IN...



High number of patches

- high *Number of Patches*
- (or low in extreme cases) - NP

Small patches

- low *Mean Patch Size* - MPS

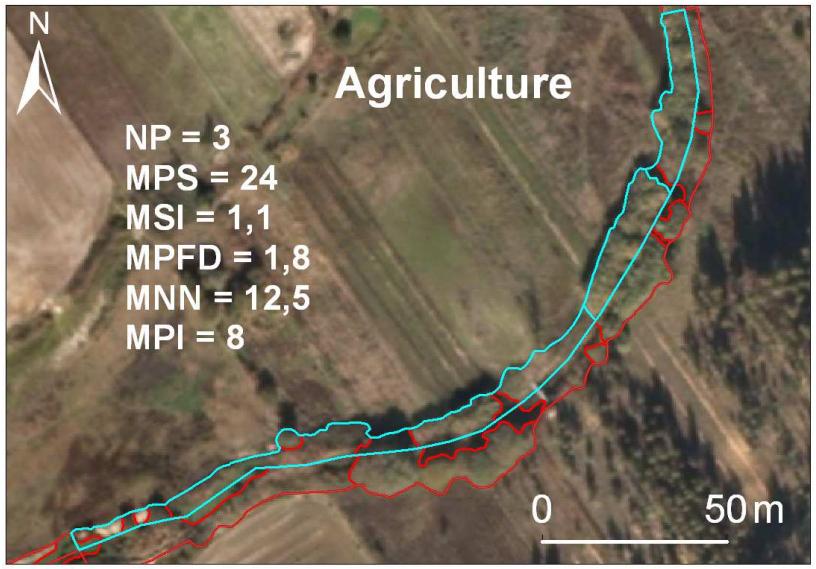
Less complex shapes

- low *Mean Fractal Dimension Index* - MPFD
- low *Mean Shape Index* - MSI

Fernandes, Aguiar & Ferreira 2011/Landscape and Urban Planning 99(2):166-177.

CASE STUDY – LAND USE

IT IS EXPECTED THAT DEGRADATION RESULT IN...



Isolated patches

- high *Mean Nearest-Neighbor Distance* -MNN
- Low *Mean Proximity Index* - MPI

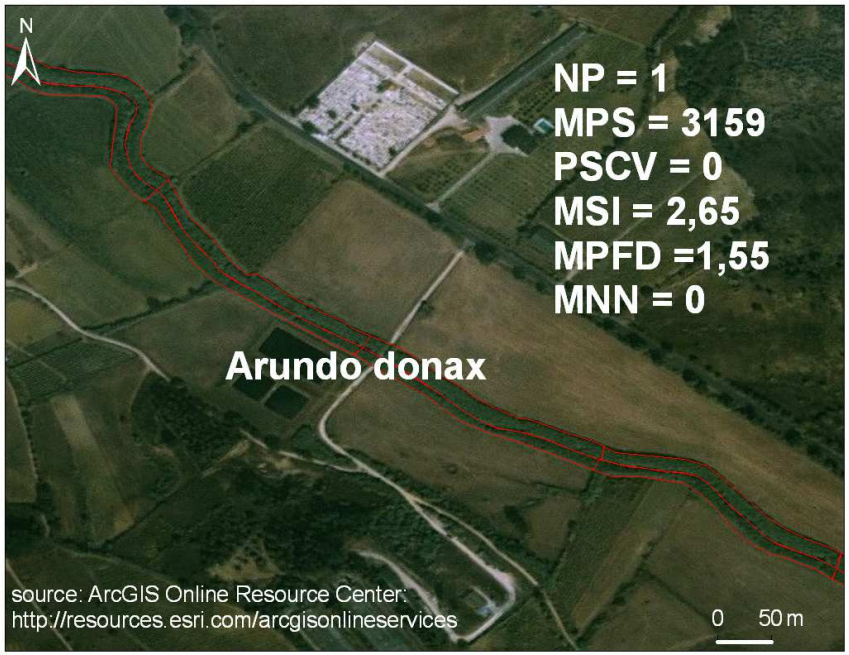
Homogeneous patches

- low Patch Size Coefficient of Variation - PSCV

Low interspection of patch distribution

- Low interspection and Juxtaposition Index - IJI

ALIEN PLANT INVASIONS

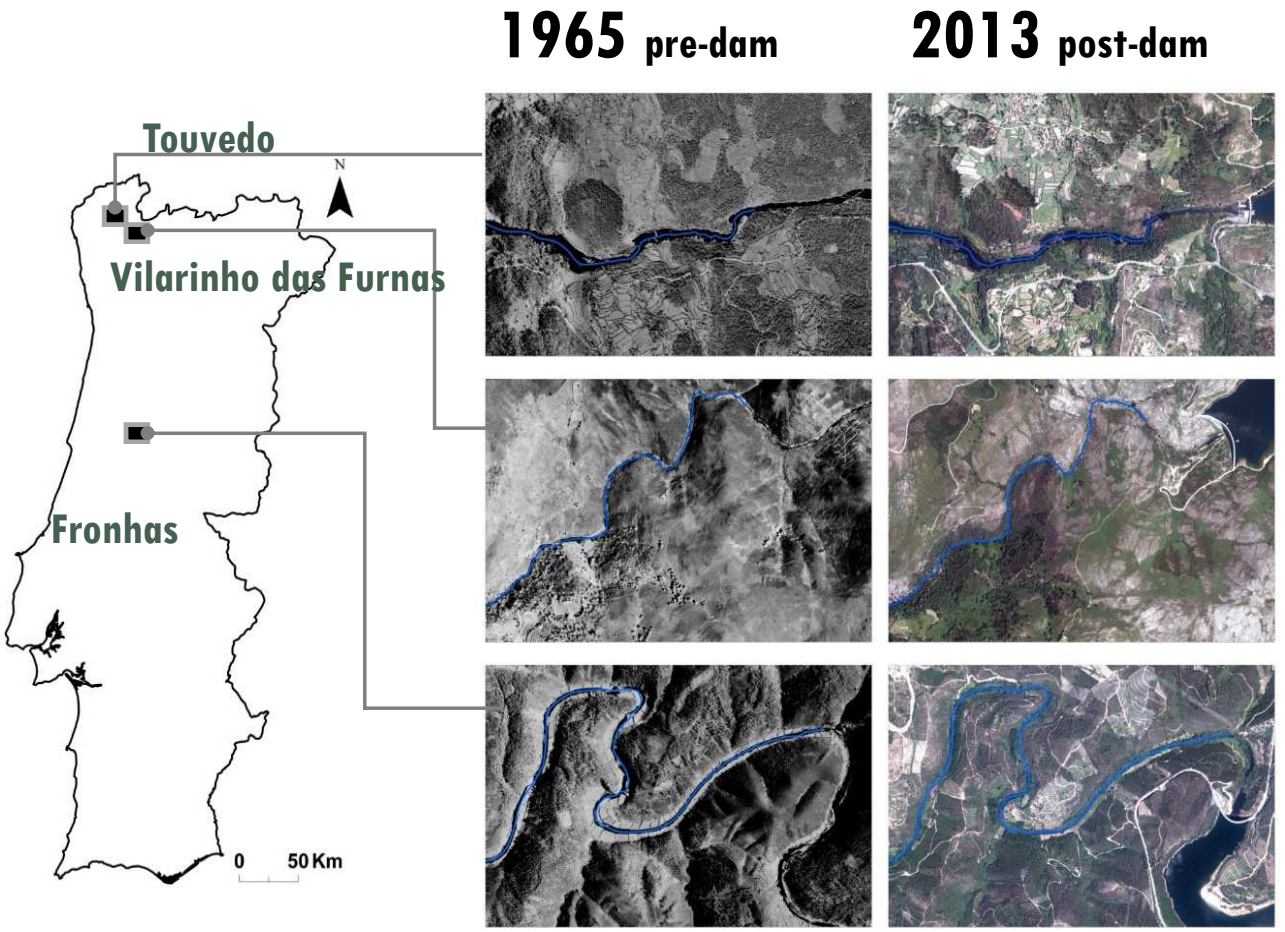


River Aveiras, CWPortugal

CASE STUDY 3

EFFECTS OF REGULATION

ON SPATIAL STRUCTURE

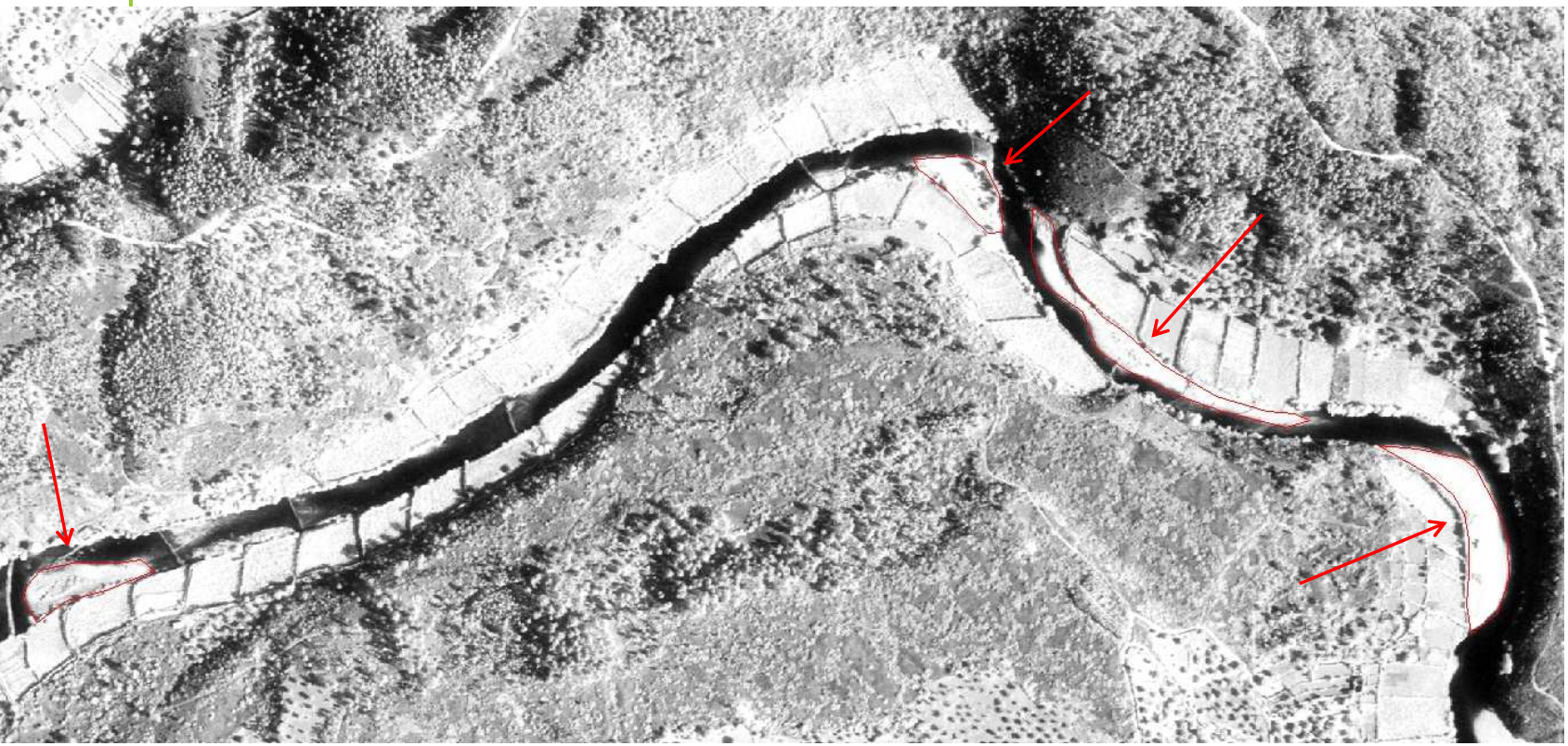


Aguiar et al. 2016/ Landscape and Urban Planning 153: 83-98.

Blue line represents the talweg

Spatial structure of riparian forests downstream dams

Fronhas: pre-dam



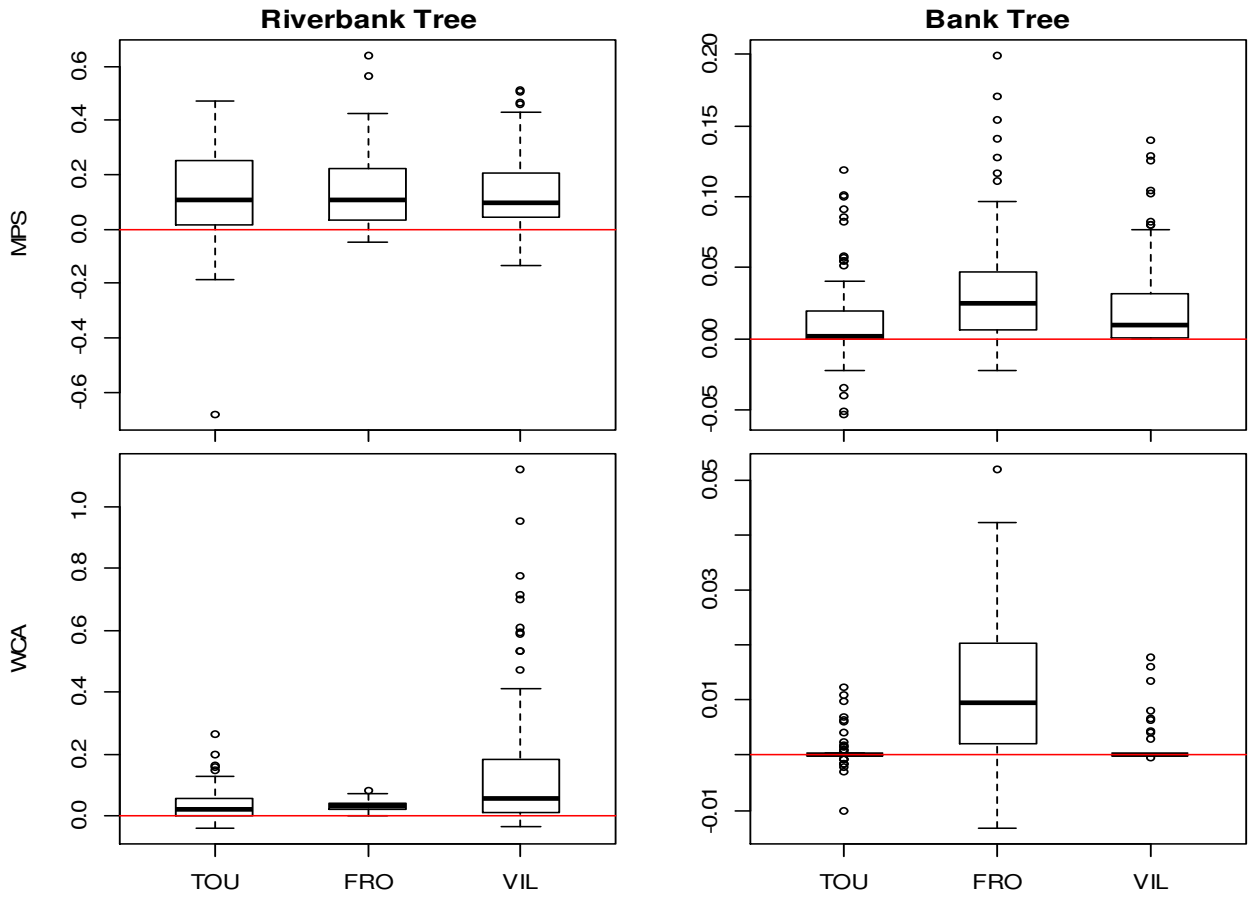
Fronhas: post-dam

Highly-altered riverscapes

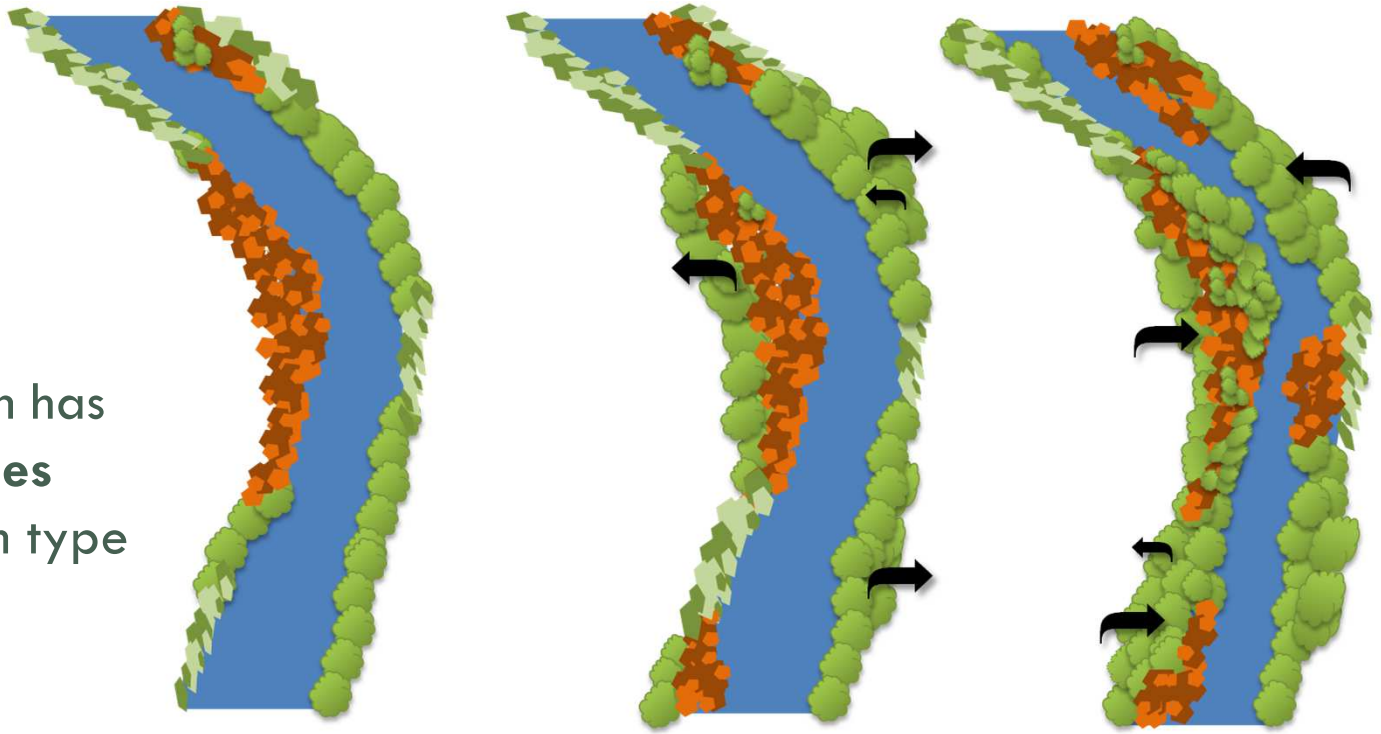
Differences post-dam vs. pre-dam ('variable difference')

Total area occupied by riparian woodlands **increased** (WCA) and riparian patches are **larger** (MPS) in the post-dam period.

TOU – Touvedo
FRO – Fronhas
VIL – Vilarinho das Furnas



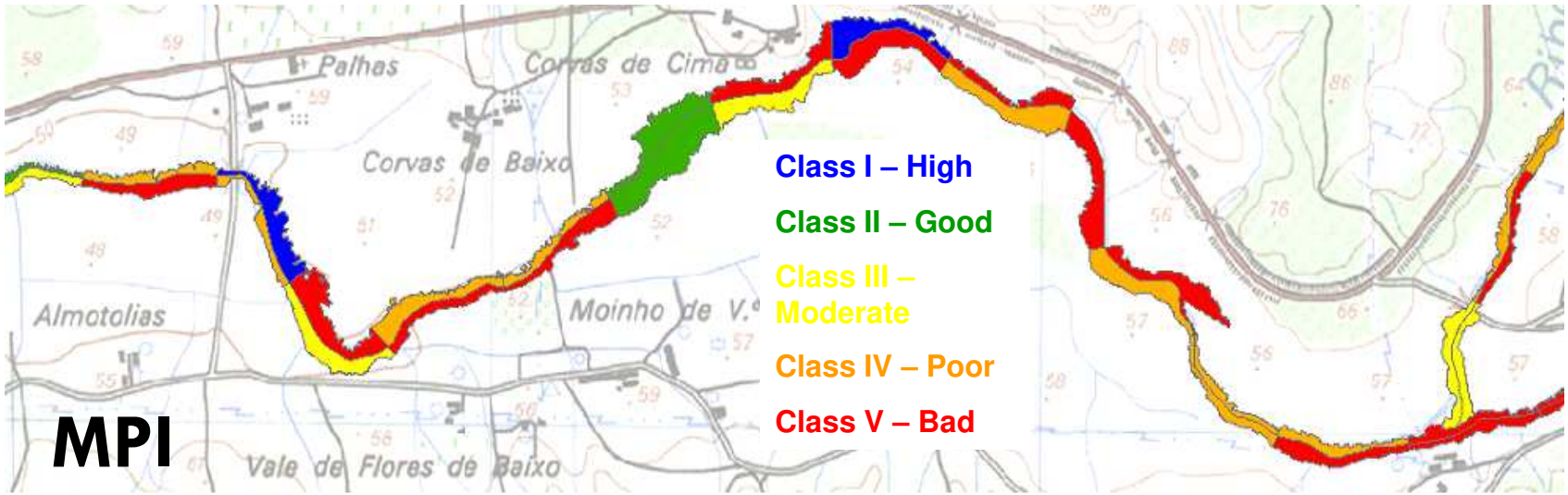
Riparian expansion has **different trajectories** depending on dam type (WCA/MPS)



Pre-dam	*Run-of-rivers (RUN)*	*Reservoir rivers (RES)*	*Comparison*
	Post-dam		
Riverbank Tree	↑	↑	RES>RUN
Riverbank Other	↑	↓	RES<RUN
Bank Tree	↑ ns	↑	RES>RUN
Bank Other	↑	↓	RES>RUN

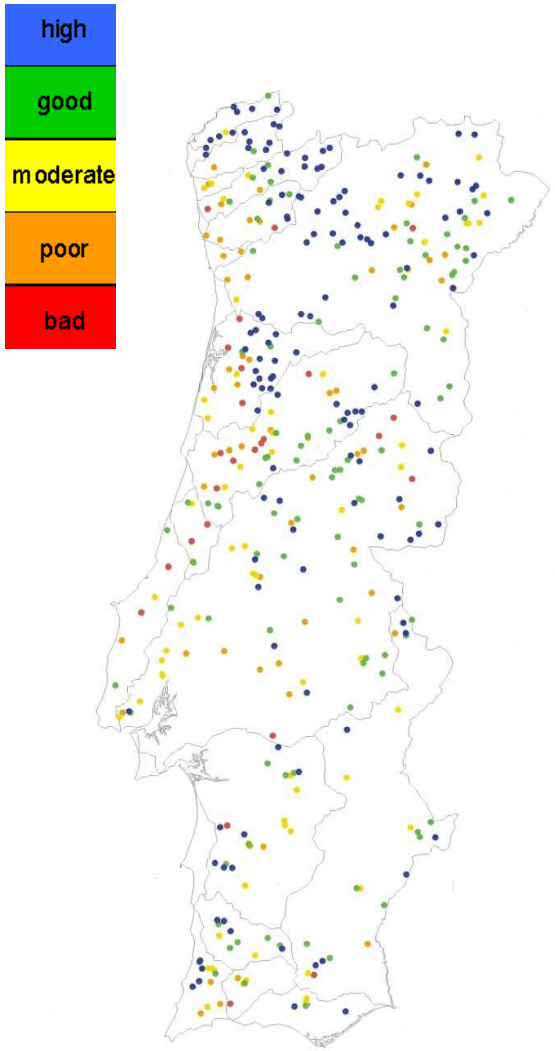
Feedback dynamics of riparian vegetation: magnitude and direction of expansion

Landscape metrics can be easily mapped on a GIS platform to visualize critical areas, manage or monitor the success of the restoration/ conservation actions.



LOCAL LEVEL

CASE STUDY 2 RIPARIAN VEGETATION INDEX



Aguiar et al., 2009. Fundamental and Applied Limnology 175:249-267

Compositional , functional and structural traits

Pre-selection of candidate metrics (from 300 plant traits)

- **Bibliographic research**
- **Expert opinion**

Alien species cover

Nºof acidophyllous species

Ruderal species cover

Average riparian width

Screening and evaluation

5 Categories

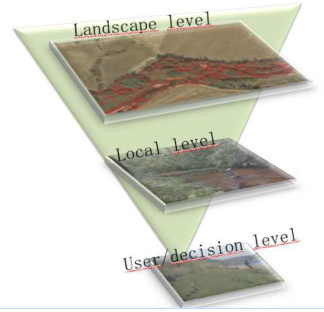
- **Composition and diversity**
- **Life cycle and reproduction**
- **Habitat resources**
- **Nutritional resources**
- **Riparian structure**

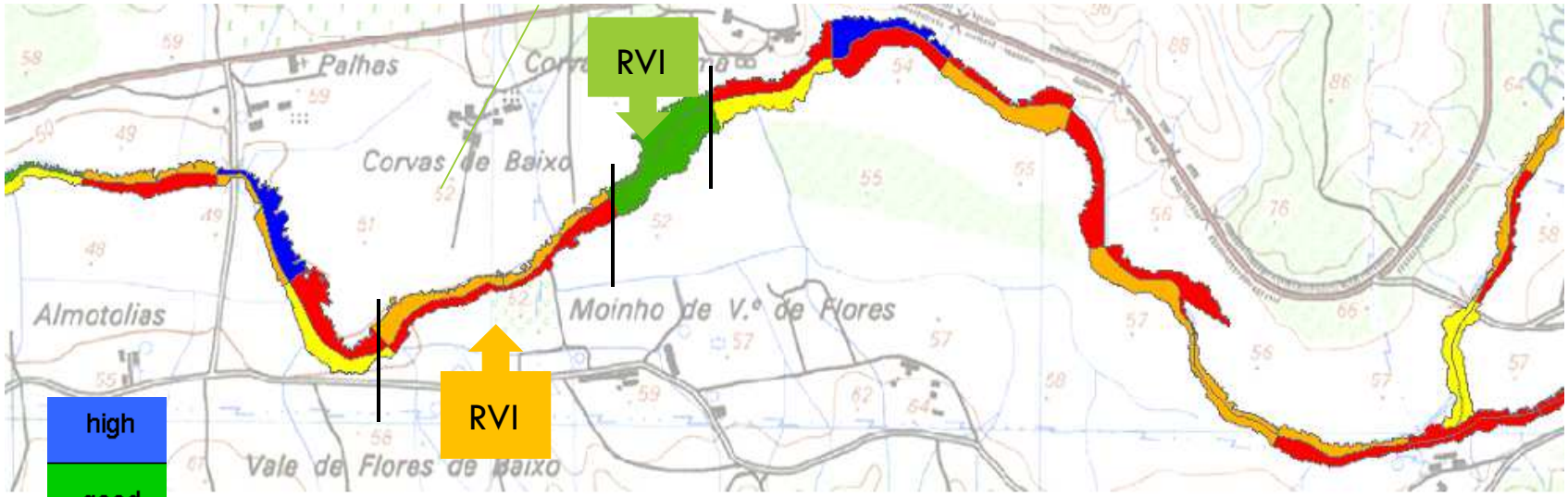
Aguiar et al. 2009/ Fundamental and Applied Limnology 175:249-267

Riparian Vegetation Index

Core metrics		North			South		
		5	3	1	5	3	1
Total richness (n°)					≥62	55.5-62	<55.5
Proportion of endemic species (%)		≥5.2	3.2-5.2	<3.2	≥1.9	0.1-1.9	<0.1
Proportion of hygrophytes (%)		≥59.6	0.5-59.6	<0.5	≥41.8	0.5-41.8	<0.5
Proportion of acidophyllous species (%)		≥12.7	8.7-12.7	<8.7	≥5.7	2.8-5.7	<2.8
Proportion of perennial species(%)		≥84	76.5-84	<76.5			
Cover of *Carex elata* subsp. *reuteriana* (%)		≥0.7	0.1-0.7	<0.1			
Proportion of alien species (%)		≤ 4.8	4.8-8	>8	≤ 3.7	3.7-7.9	>7.9
Cover of alien species (%)		≤ 0.5	0.5-2.8	>2.8	≤ 0.5	0.5-4.8	>4.8
Proportion of nythrophyllous species (%)					≤ 3.9	3.9-6.5	>6.5
Number of bulbous species (n°)					≤4	4-15.5	>15.5
Proportion of ruderals (%)		≤ 8.3	8.3-11.4	>11.4			
Weighted woody cover		≥3.3	0.7-3.3	<0.7	≥6.5	0.6-6.5	<0.6
Cover of *Erica arborea*+ *Frangula alnus* (%)		≥0.4	0.1-0.4	<0.1			
Boundaries in Ecological Quality Ratio values	High/Good		0.67			0.75	
	Good/Moderate		0.50			0.56	
	Moderate/Bad		0.33			0.37	
	Bad/Poor		0.16			0.19	

INTEGRATION





high
good
moderate
poor
bad

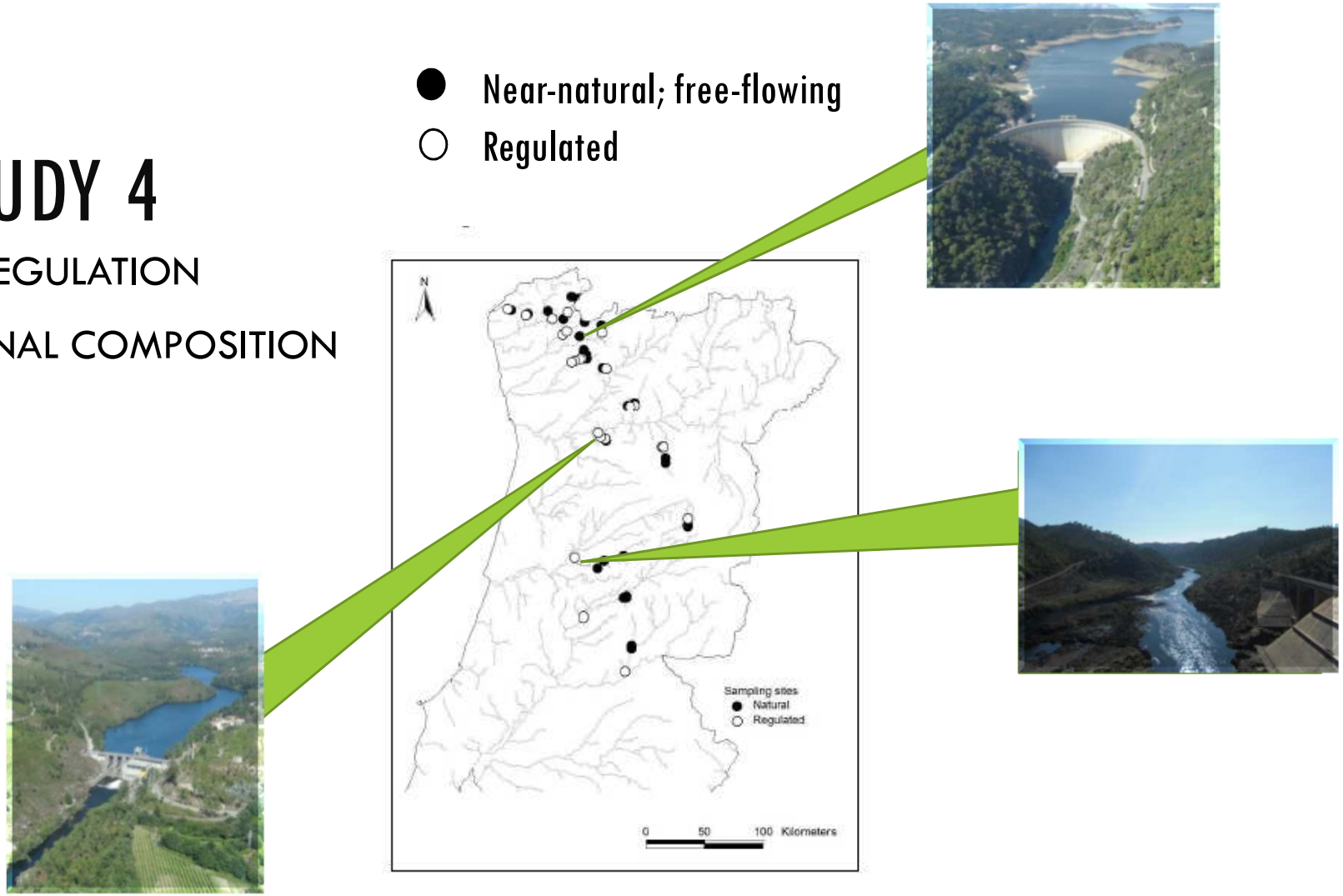
Riparian cover
+
Exotic cover
+
Hygrophytes

MPI
MPFD
MNN
NP

CASE STUDY 4

EFFECTS OF REGULATION

ON FUNCTIONAL COMPOSITION



Aguiar et al. 2018./Journal of Applied Ecology. doi: 0.1111/1365-2664.13110

FLOWBASE - A Riparian Plant Traitbase

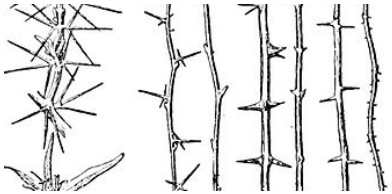
HOME ABOUT CONTACTS

Click the buttons->

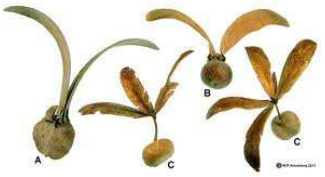
TRAITS

Click the buttons->

LOCALS



http://www.isa.ulisboa.pt/proj/flowbase/



16 case studies (hydropower rivers); 20 dams; 52 sampling sites/field surveys; 28 traits

Obligate riparian guild [e.g. *Alnus glutinosa, Salix* sp., *Frangula alnus*]

Salix salviifolia

Water stress tolerant [e.g. *Rubus ulmifolius, Rosa* sp., *Ulex minor*]

Rosa pouzinii

Deciduous competitive [e.g. *Fraxinus angustifolia, Quercus* sp., *Sambucus nigra*]

Fraxinus angustifolia

Mediterranean evergreen [e.g. *Myrtus communis; Arbutus unedo*]

Myrtus communis

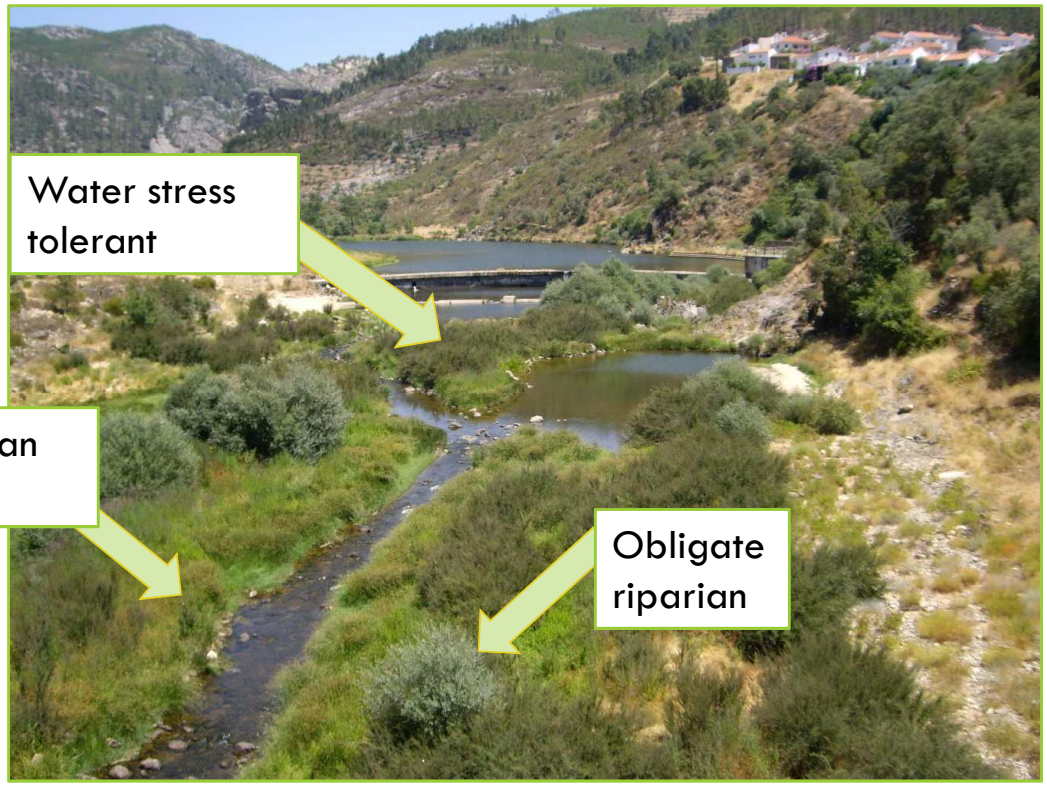
Non-riparian evergreen [e.g. *Erica cinerea; Cistus psilosepalus; Flueggea tinctoria*]

Flueggea tinctoria

Preferential riparian [*Betula pubescens spp. celtiberica; Laurus nobilis*]

Betula pubescens spp. celtiberica

Riparian guilds alter their distribution and abundance, but not the frequency of occurrence.



RESEARCH ARTICLE

Journal of Applied Ecology

The abundance and distribution of guilds of riparian woody plants change in response to land use and flow regulation

Francisca C. Aguiar[1] | Pedro Segurado[1] | Maria João Martins[1] | Maria Dolores Bejarano[2] | Christer Nilsson[2] | Maria Manuela Portela[3] | David M. Merritt[4]

RESEARCH ARTICLE*

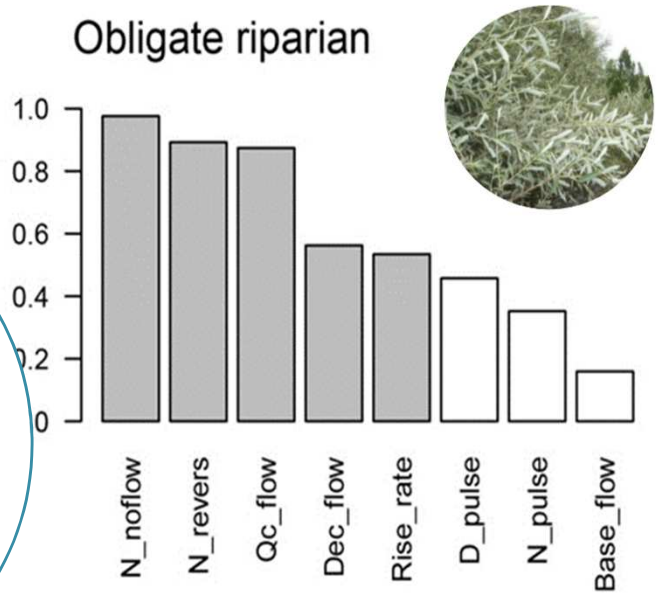
Journal of Applied Ecology

Riparian plant guilds become simpler and most likely fewer following flow regulation

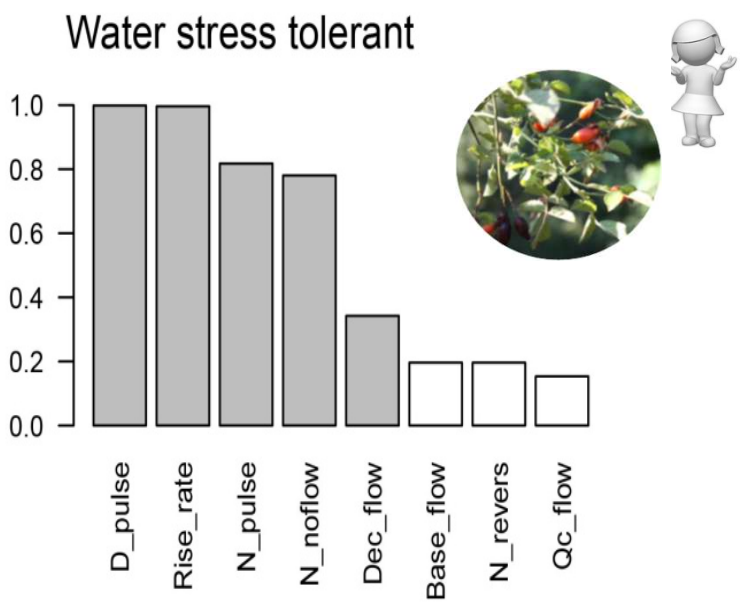
Maria Dolores Bejarano[1] | Christer Nilsson[1] | Francisca Constança Aguiar[2]

Frequency and duration of high flow pulses and the low-flow conditions were major drivers of change

Obligate, hydrochoric dispersal waterlogging tolerants, competitors



Nr. of days with no flows

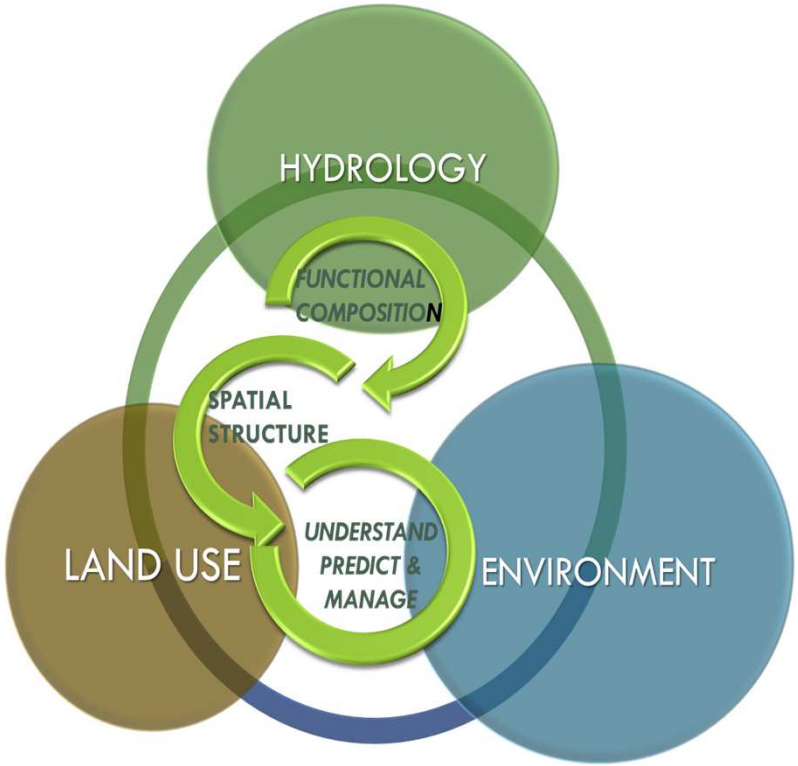


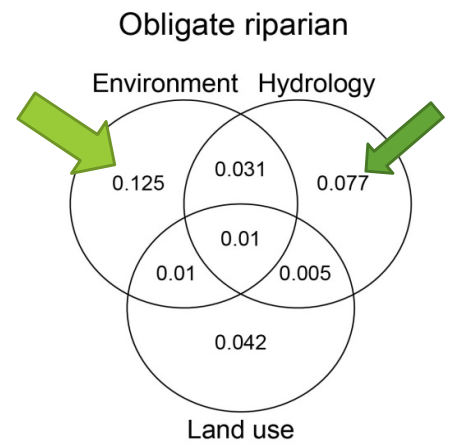
Duration of high pulses Rise rates

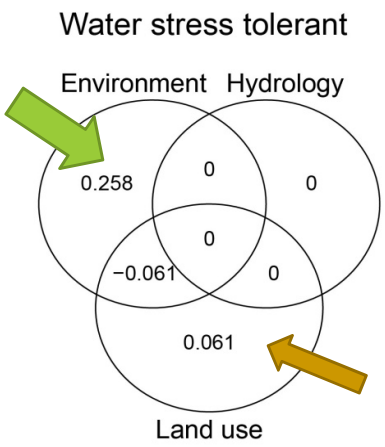
Facultative riparian, water stress tolerants, physical defenses, deep roots

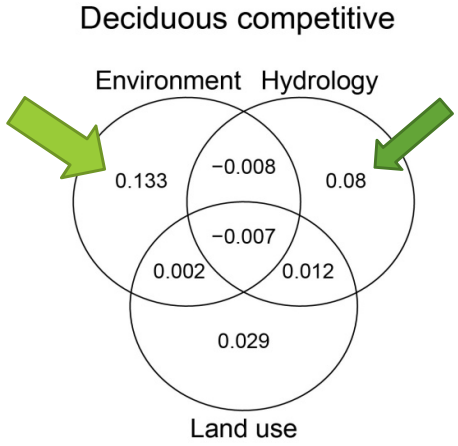
Best model variables – grey bars

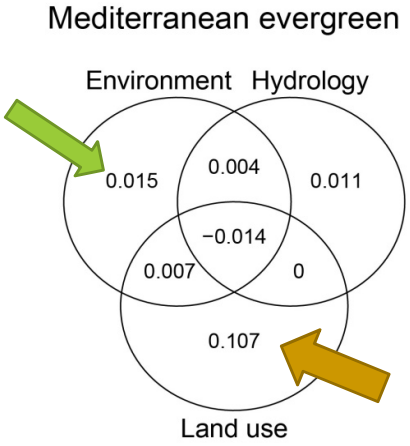
Complex pattern on the partial contribution of environment, hydrology & land use



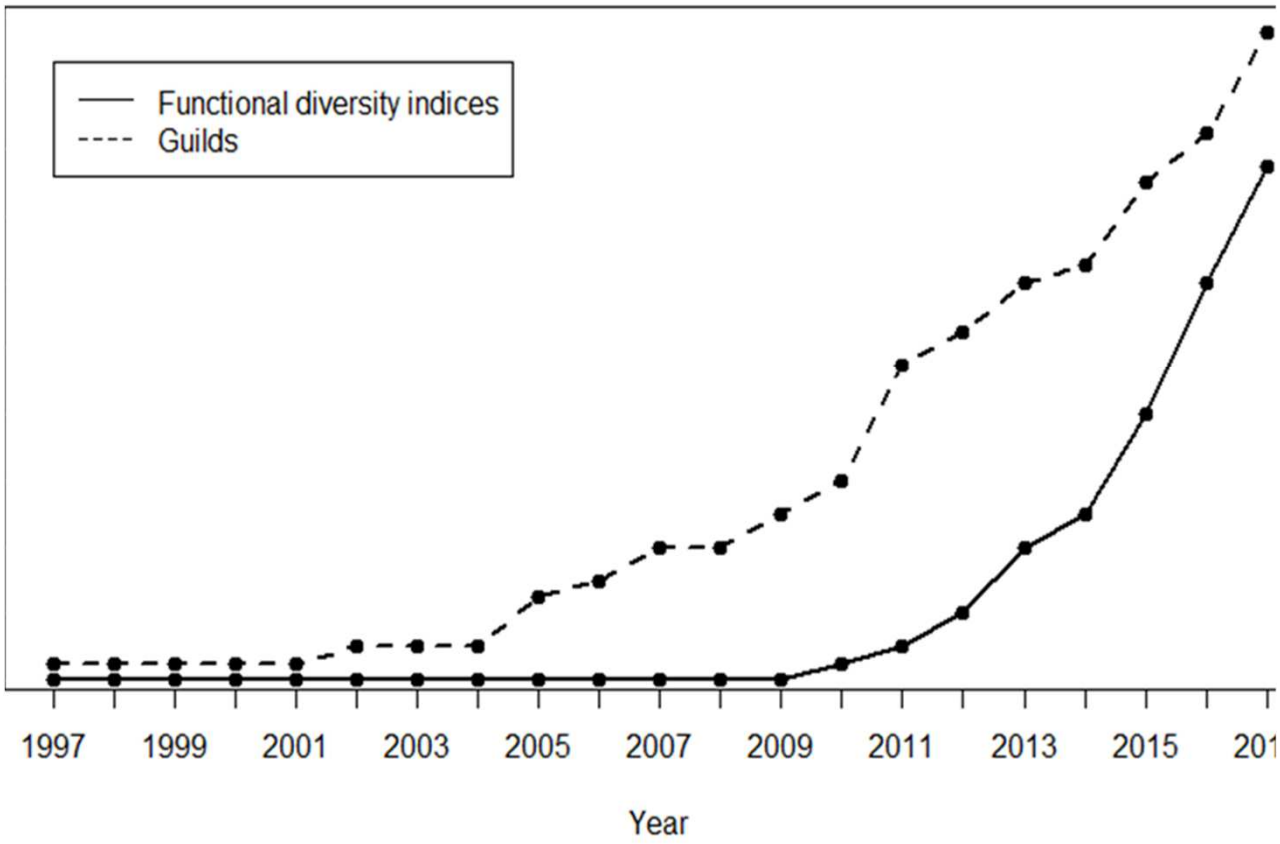




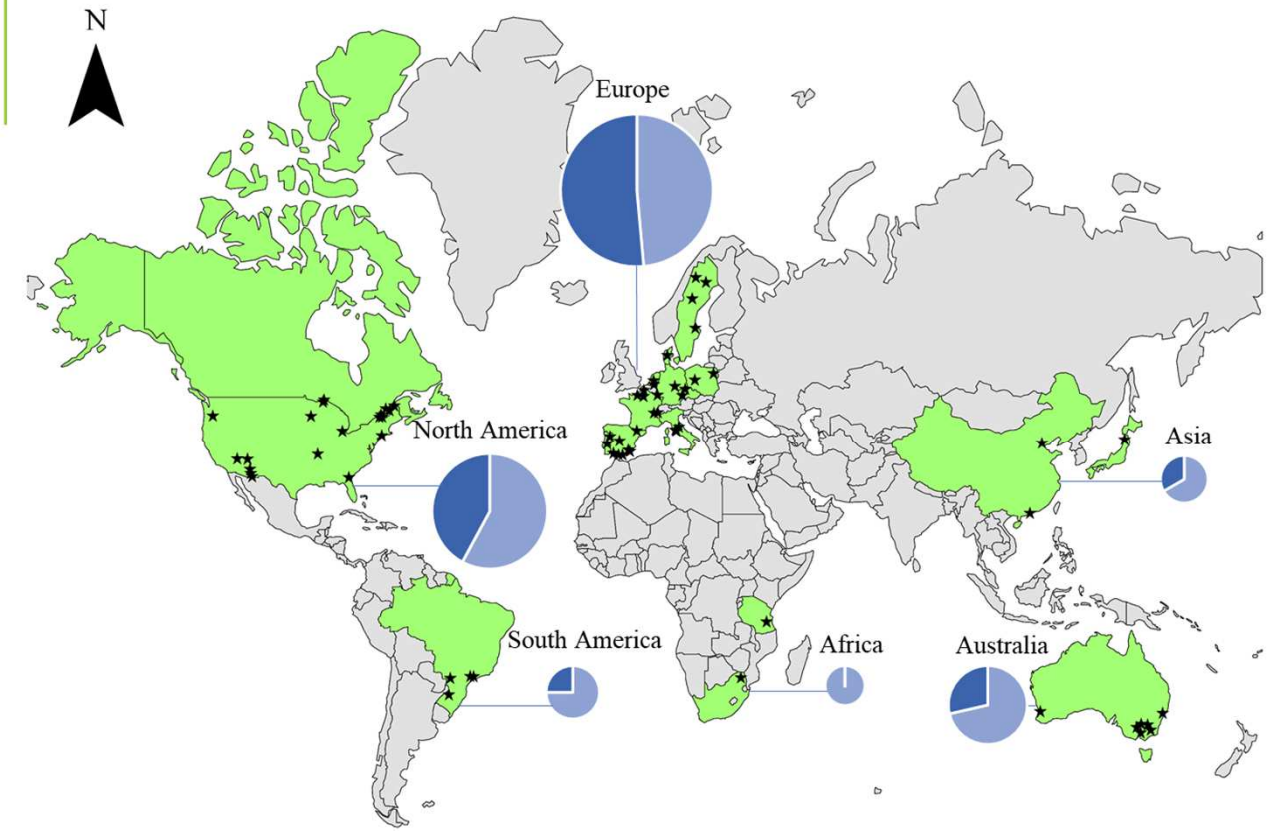


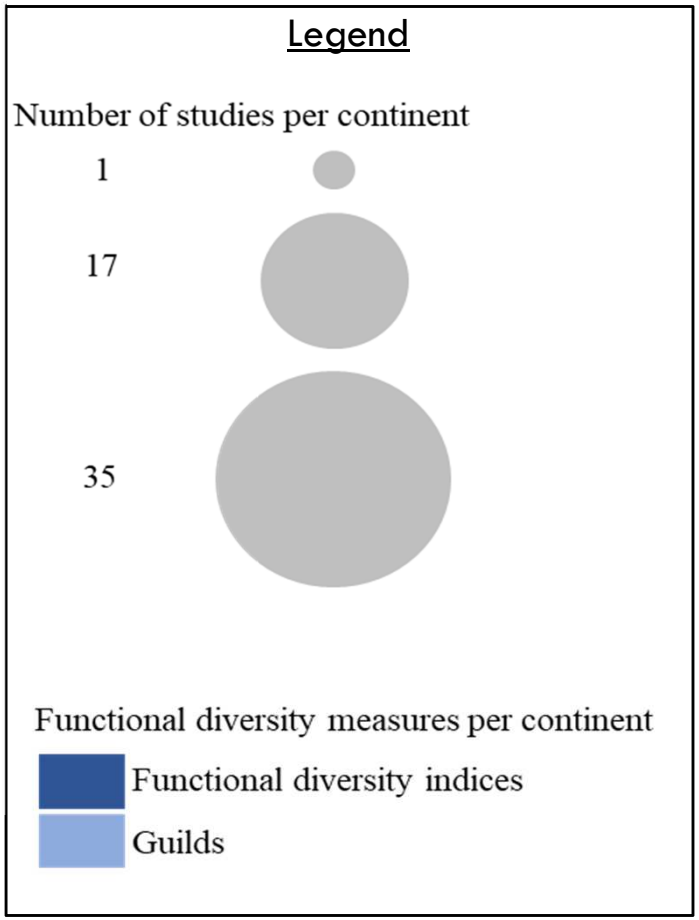


GUILDS & INDICES



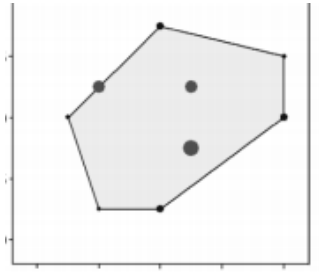
Lozanovska, Ferreira & Aguiar (Ecological Indicators submitted; in revision)



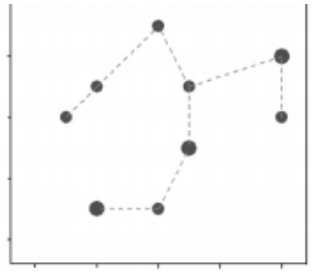


Lozanovska, Ferreira & Aguiar (Ecological Indicators submitted; in revision)

Functional diversity index	% studies
Functional Richness (FRic)	25.7
Functional Evenness (FEve)	20.3
Functional Divergence (FDiv)	17.6
Functional Dispersion (FDis)	13.5
Rao (Q)	4.1
Functional Redundancy (FR)	2.7
Extended functional diversity (wFDc)	2.7
Functional Diversity (FD)	1.4
Modified Functional Attributes Diversity (MFAD)	1.4
Community based functional diversity (FDc)	1.4
Community Weighted Means (CWM)	9.5



FRic



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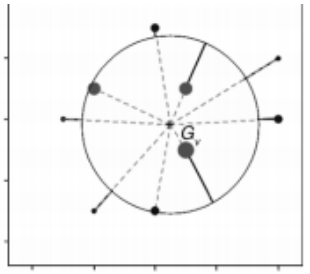


FDiv

Lozanovska, Ferreira & Aguiar (submitted; in revision)

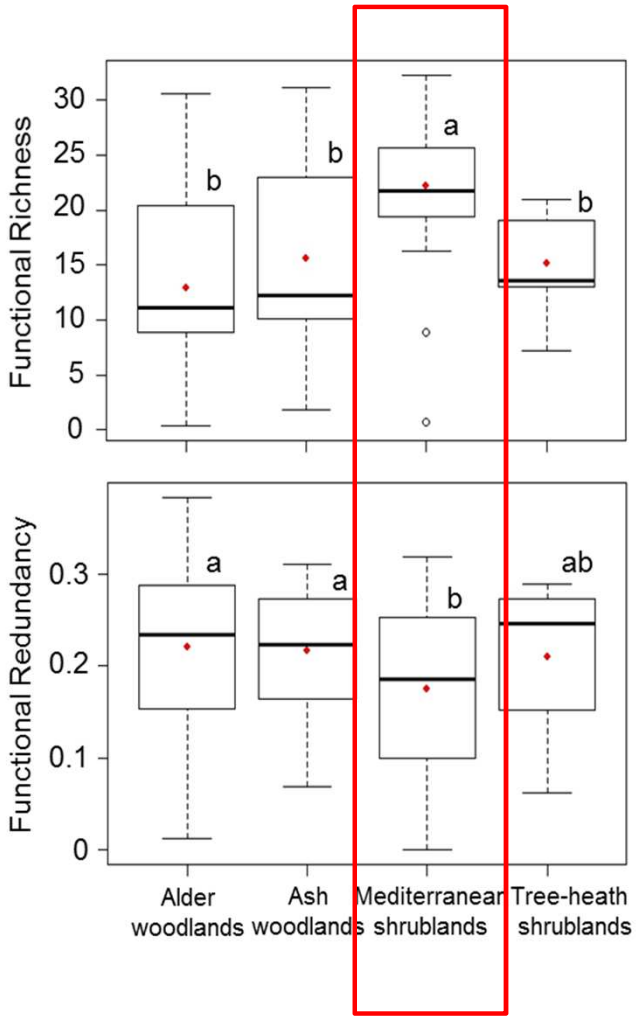
CASE STUDY 5

Alder woodlands

Ash woodlands

Mediterranean shrublands

Tree-heath shrublands



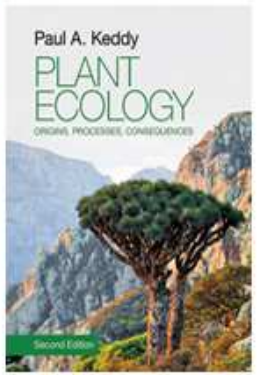
Lozanovska et al. 2018/Aquatic Sciences 80

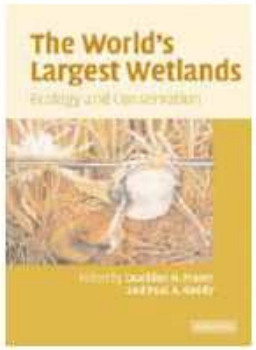
III. KNOWLEDGE CONVERSION
10 THOUGHTS

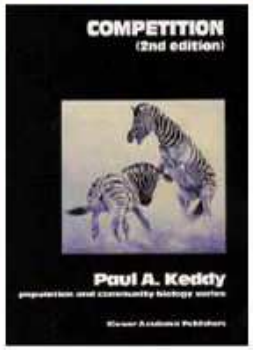
THOUGHT 1

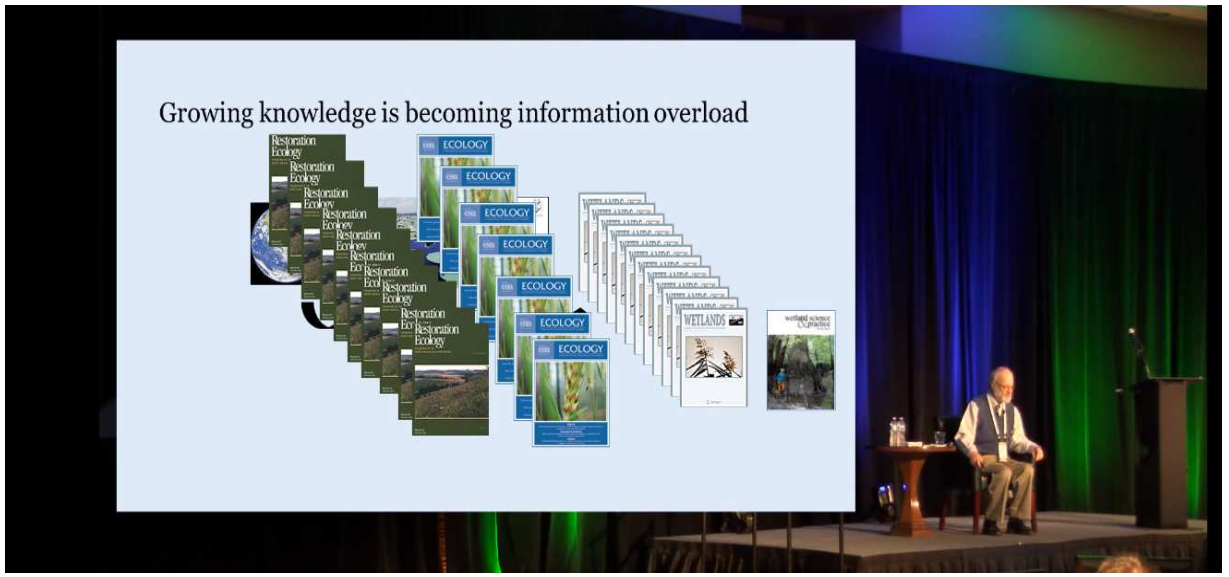
WE SHOULD NOT REINVENT THE WHEEL!

Photo credits: Hermin Abramovitch

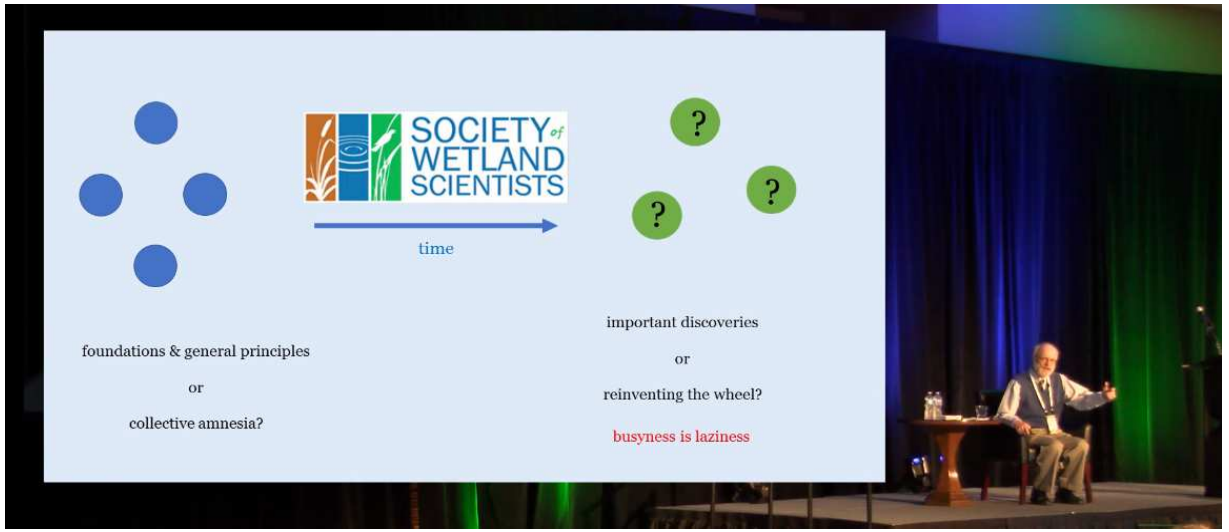






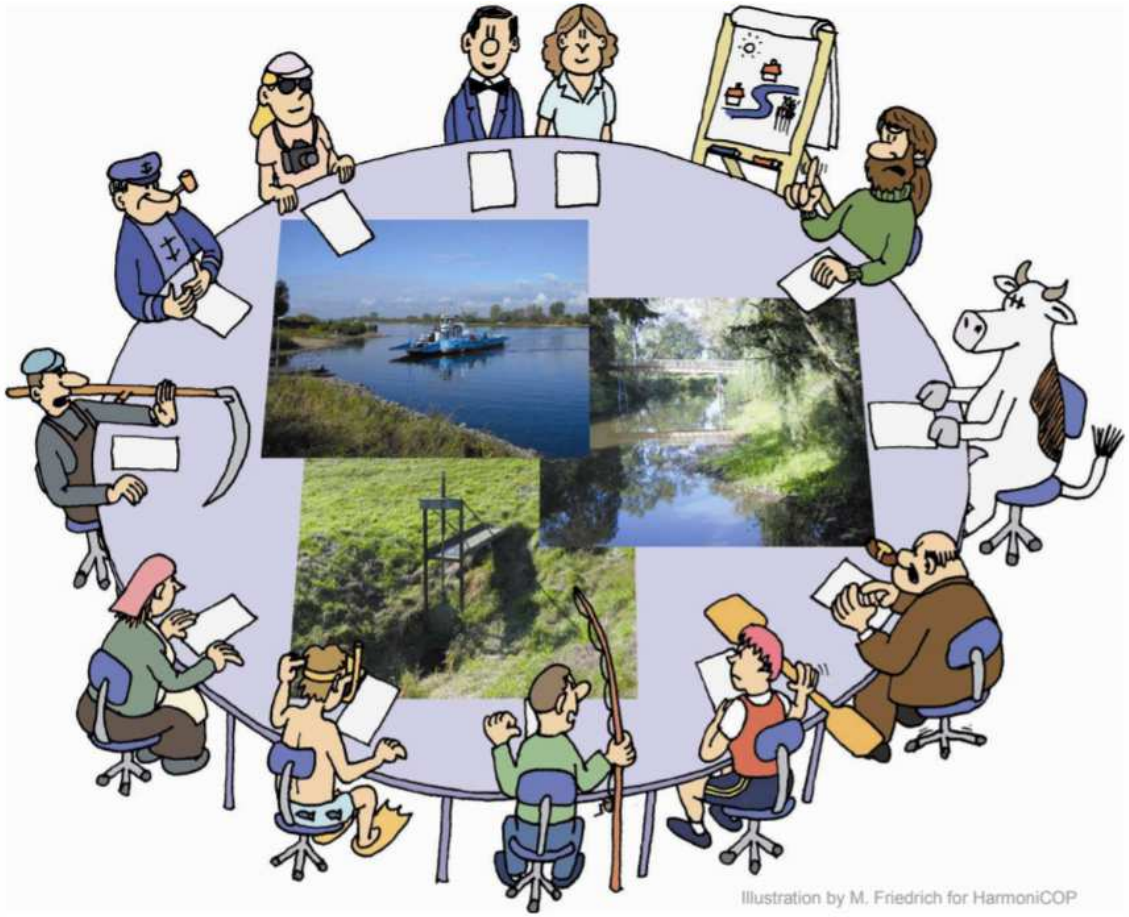


https://vimeo.com/274807365 Dr. Paul Keddy

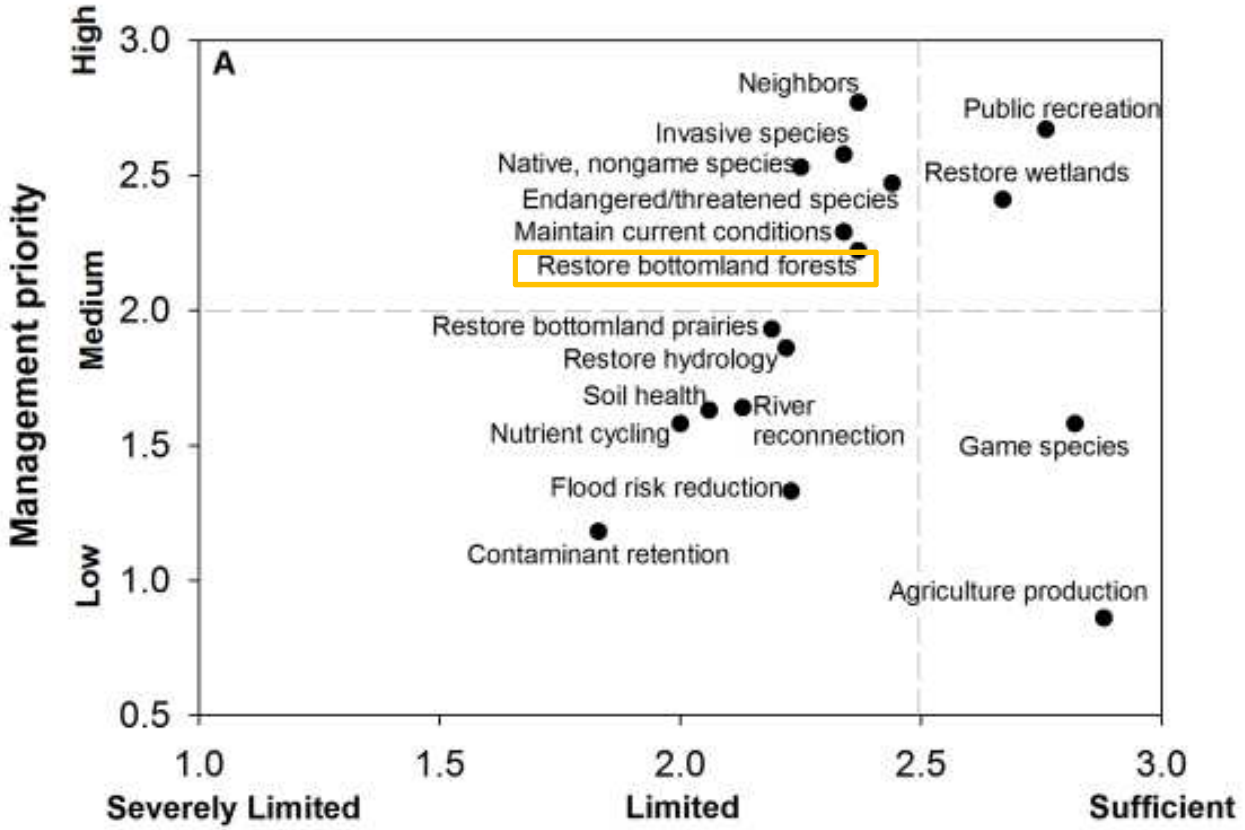


THOUGHT 2

CHALLENGE – FIND COMMON WAYS TO DIFFERENT VIEWS FOR SUSTAINABLE MANAGEMENT



Average survey responses for management priority and level of scientific information available to manage floodplain lands



Bouska et al. 2016. Ecology and Society 21(3):12.

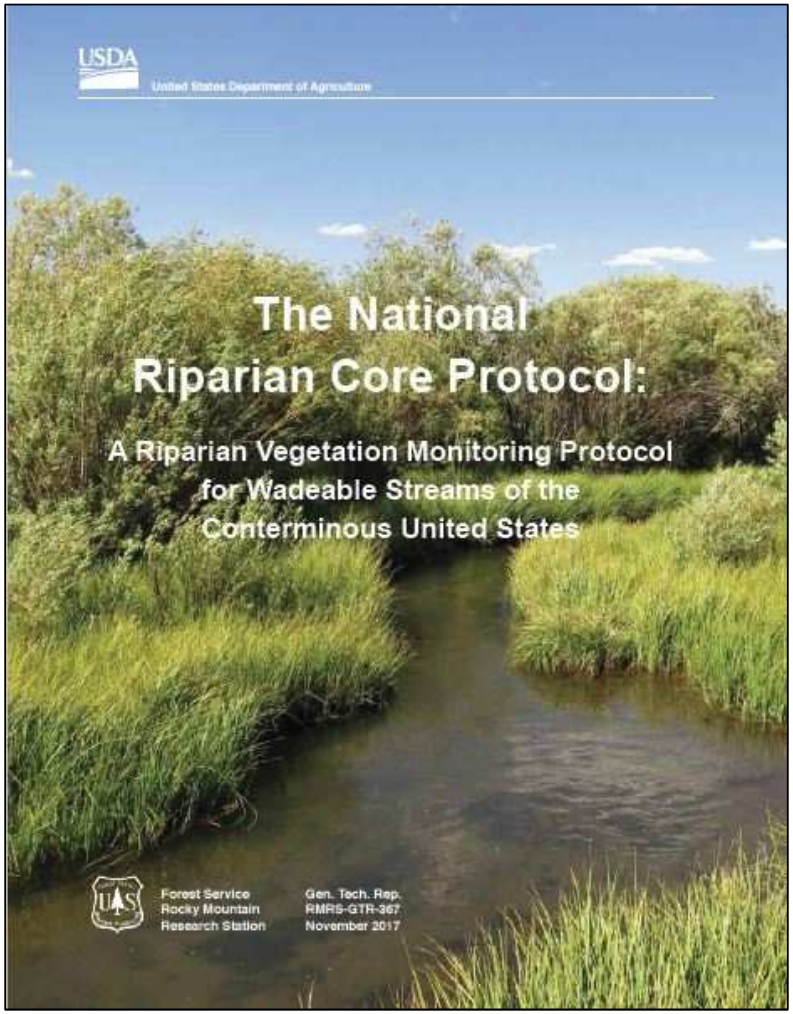
THOUGHT 3

BE AWARE OF CONTRADICTORY ECOSYSTEM SERVICES

Examples: carbon sequestration and conservation values; social and conservation values

THOUGHT 4

THERE IS NOT A “ONE” SINGLE SOLUTION



Valley bottom type	Riparian transect length (m)
Headwaters	6
High-energy coupled	10
High-energy open	30
Gorge	20
Canyon	20
Moderate-energy confined	20
Moderate-energy unconfined	50
Glacial trough	40
Low-energy floodplain	70

Courtesy of D.M. Merritt (Webinar, July 2018)

Monitoring must vary as a function of region, channel form, and management objective.

Field sampling protocol should be different if you are sampling a watertrack flowing through a peatland, an ephemeral stream, or a cottonwood-dominated riparian area.

Woody and herbaceous vegetation

Frequency and cover of each species

Vertical distribution of plants by species

Ground or water cover

Frequency of recruiting woody species

Courtesy of D.M. Merritt (Webinar, July 2018)

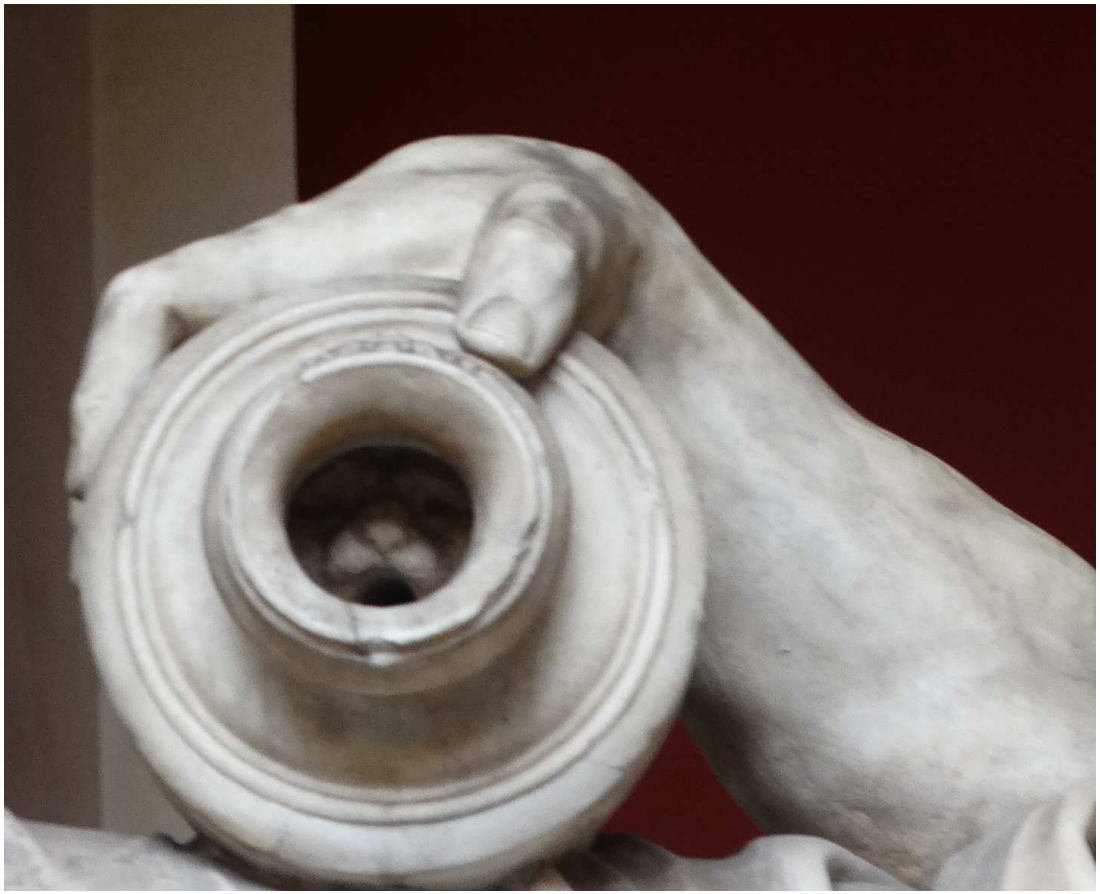
THOUGHT 5

LOOK AT THE DETAILS, INTERPRET WELL

God of the River, Vaticano Museum, Rome, Italy

THOUGHT 4

LOOK AT THE DETAILS, INTERPRET WELL



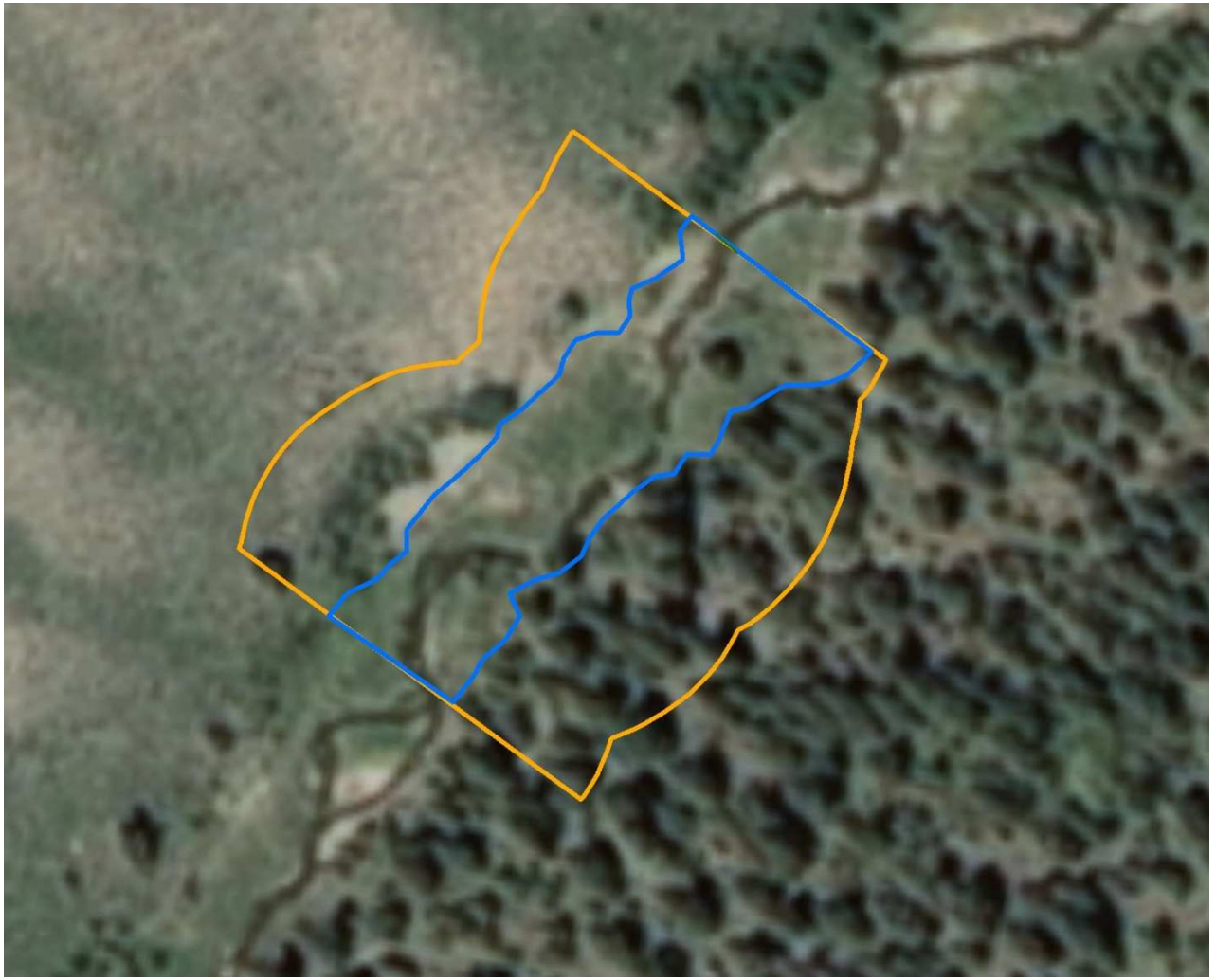
God of the River Tigris

God of the River Arno, Florence, Italy, Homage to Pope Leo X Medici

RIPARIAN AREA AND 100FT BUFFER - OVERESTIMATION IDAHO, CORRAL CREEK

Courtesy of D.M. Merritt (Webinar, July 2018)

RIPARIAN AREA AND 100FT BUFFER - OVERESTIMATION IDAHO, CORRAL CREEK

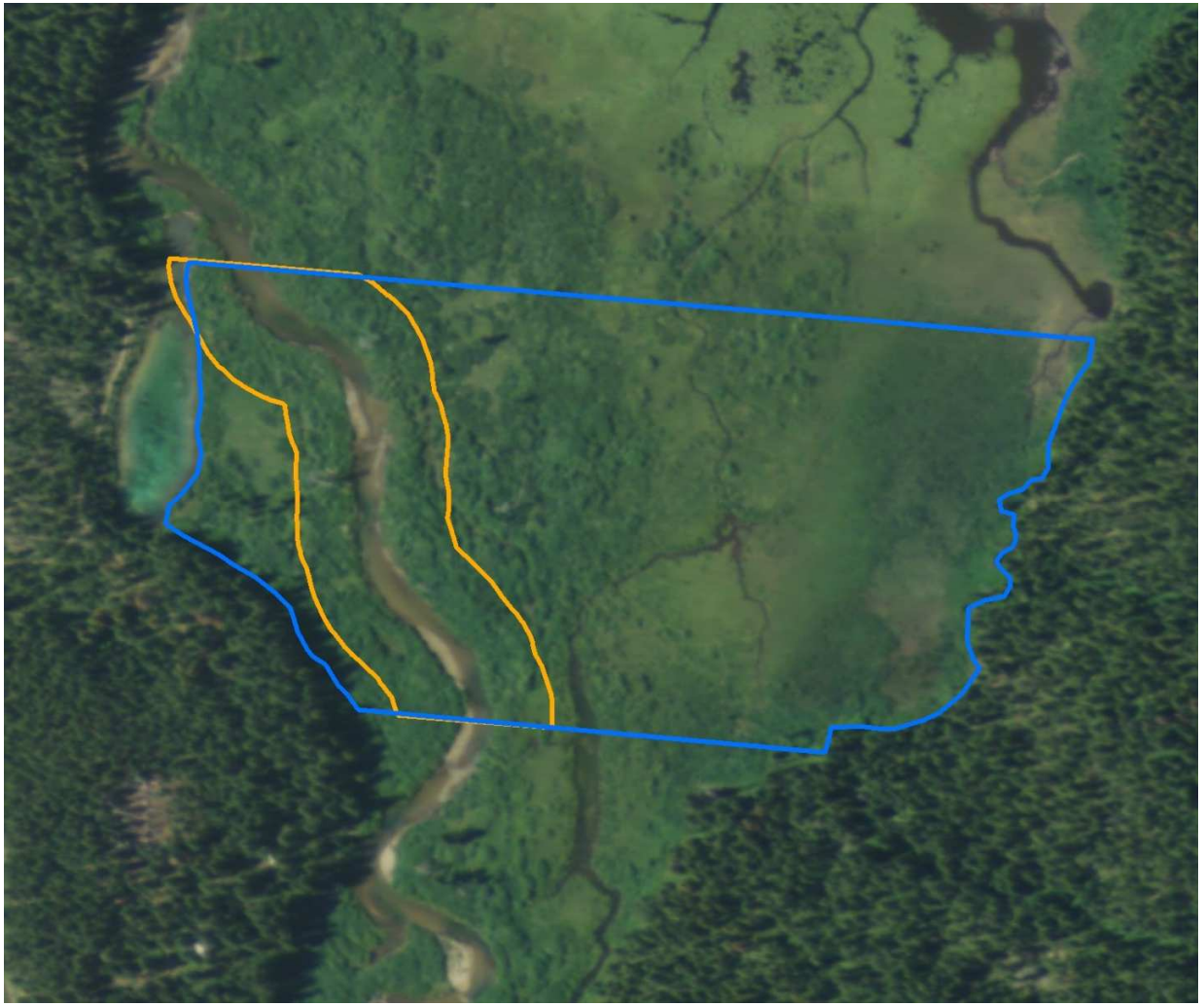


Courtesy of D.M. Merritt (Webinar, July 2018)

RIPARIAN AREA AND 100FT BUFFER - UNDERESTIMATION MONTANA, MEADOW CREEK

Courtesy of D.M. Merritt (Webinar, July 2018)

RIPARIAN AREA AND 100FT BUFFER – OMISSION ERROR MONTANA, MEADOW CREEK



Courtesy of D.M. Merritt (Webinar, July 2018)

THOUGHT 6

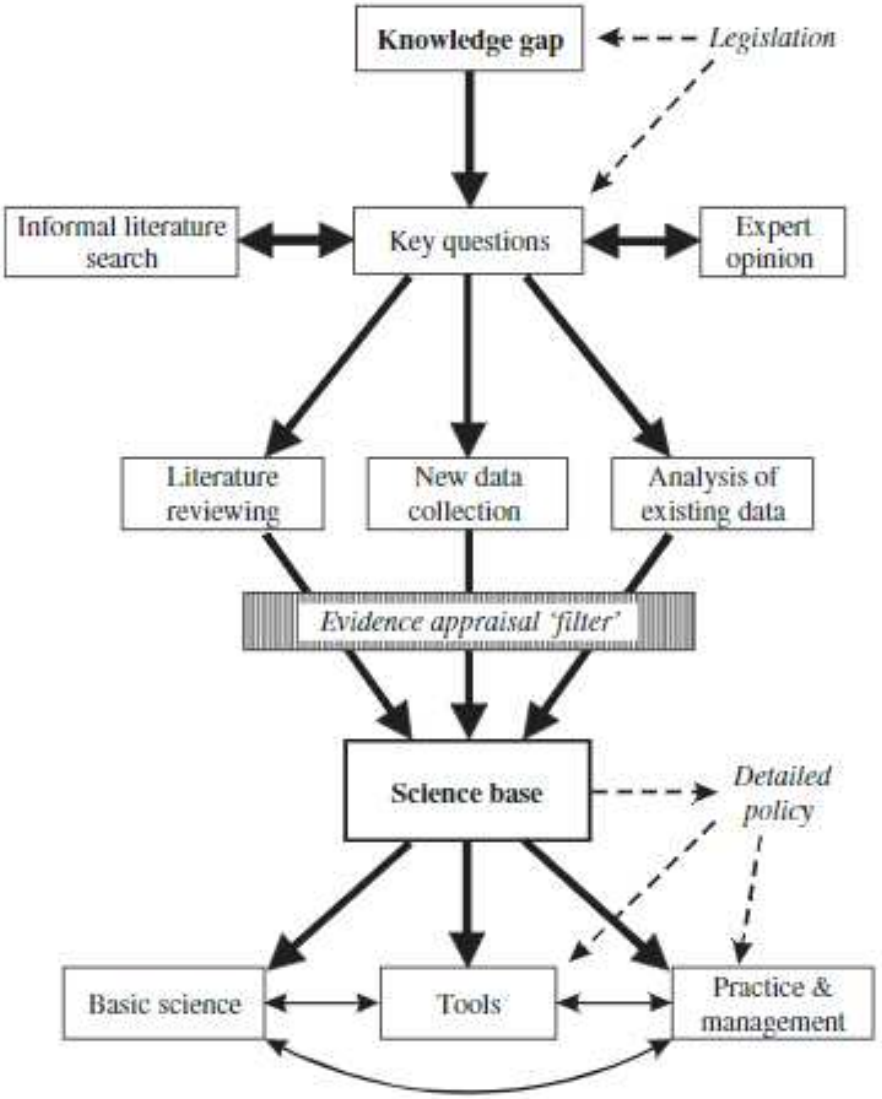
LINK SCIENCE TO THE REAL WORLD

FROM KNOWLEDGE GAP TO

UNDERSTANDING TO

MANAGEMENT

Vaughan et al. 2009/ Aquatic Conserv.: Marine & Freshwater Ecosystems 19: 113-125



"Scale-dependent effects require concerted management efforts at both the riparian and the (sub-)catchment scale.
Riparian buffer management thus needs to be accompanied by nutrient and erosion control measures at broader scales."

Feld et al. 2018/ Water Research 139: 381-394.

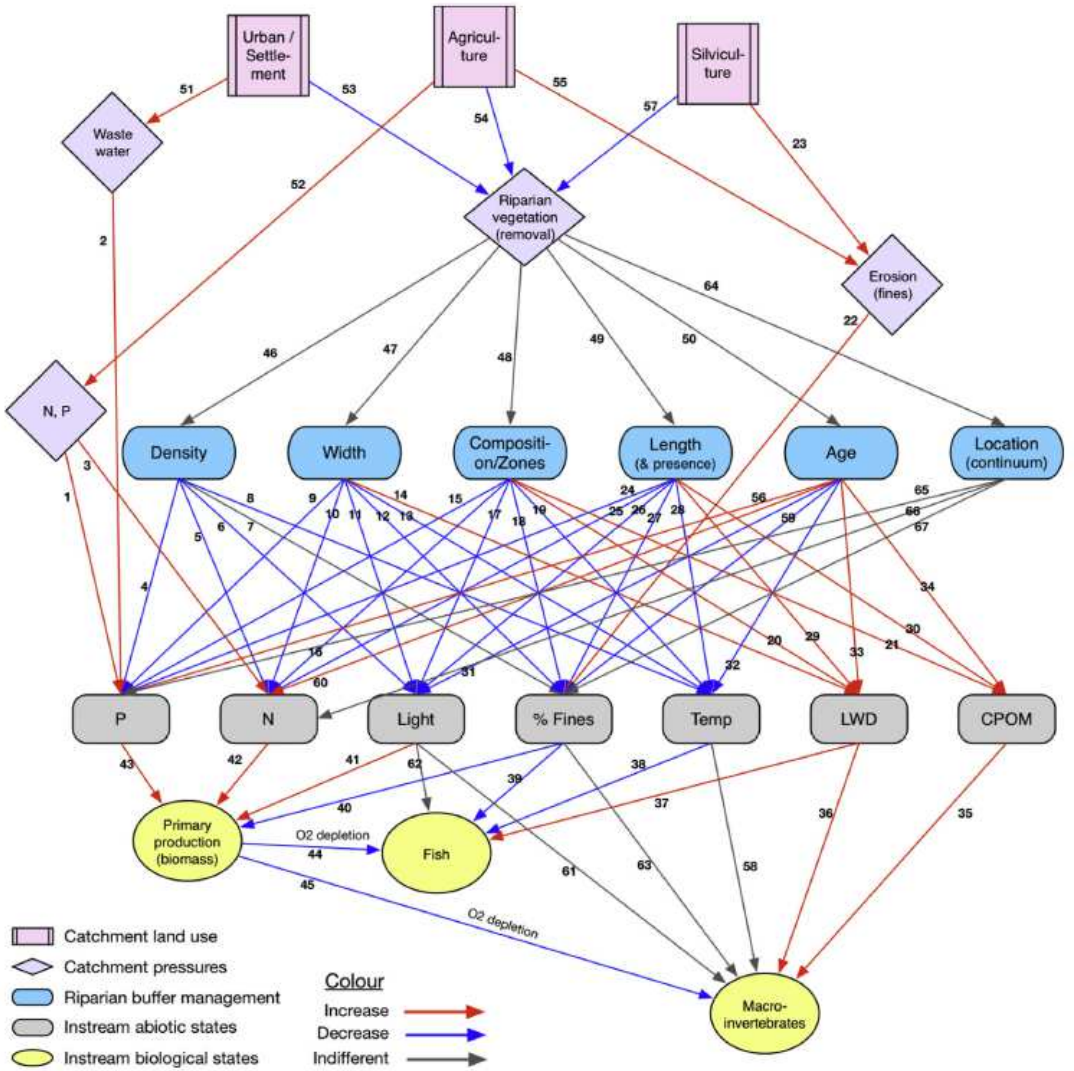


Fig. 1. Conceptual model showing the hypothesised hierarchical relationships between catchment drivers of impact (land-use), catchment pressures, riparian buffer manager instream environmental and biological states. Blue arrows represent assumed negative relationships, red arrows assumed positive relationships and grey arrows assumed un effects, i.e. both positive and negative relationships are possible. (See Supplementary Table S1 for the linkage of arrow numbers and core references.). (For interpretation c references to colour in this figure legend, the reader is referred to the Web version of this article.)

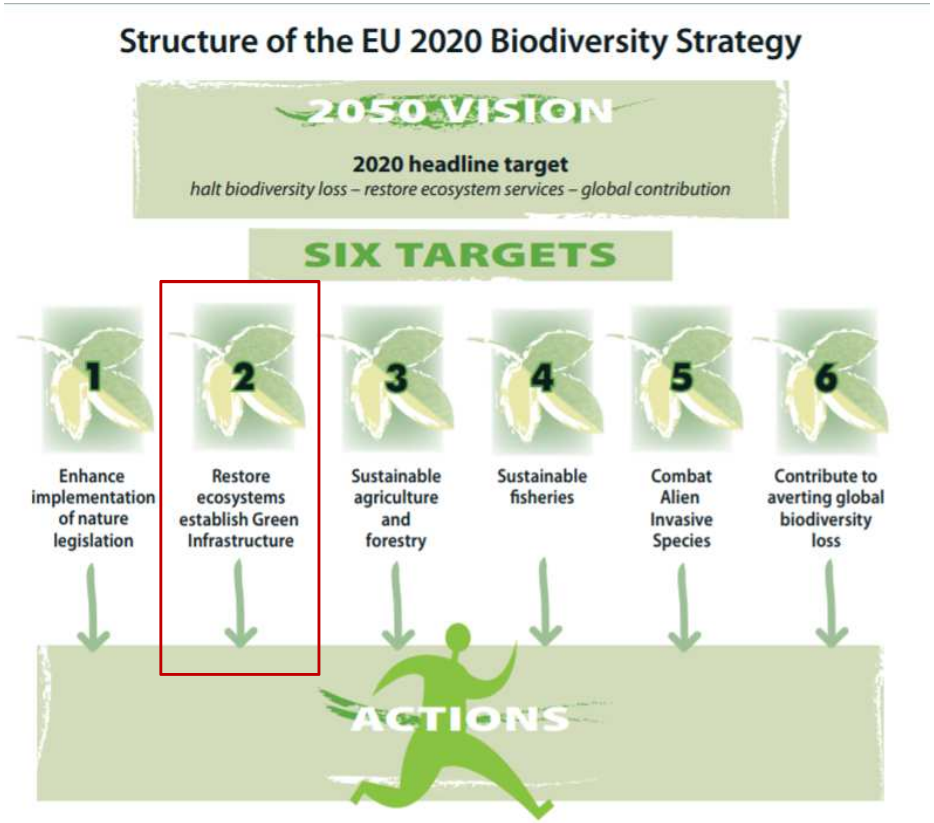
THOUGHT 7

A COMMON SCALE, A COMMON TERMINOLOGY: THERE ARE STILL DIFFICULTIES IN TRANSFER KNOWLEDGE

"If we all are zebras, why are we so different?..."

THOUGHT 8

INTEGRATION OF LEGISLATION



CHALLENGE - LEGISLATION

•EU Biodiversity Strategy to 2020, in particular mapping and assessing ecosystems and their services, green infrastructure and restoration;

•Nature Directives (Habitats and Birds Directives) in the framework of the EU Biodiversity Strategy to 2020;

•Management of river basins in line with the Water Framework Directive;

•Flood protection measures in the Floods Directive;

•New initiative on Maritime Spatial Planning and Integrated Coastal Management.

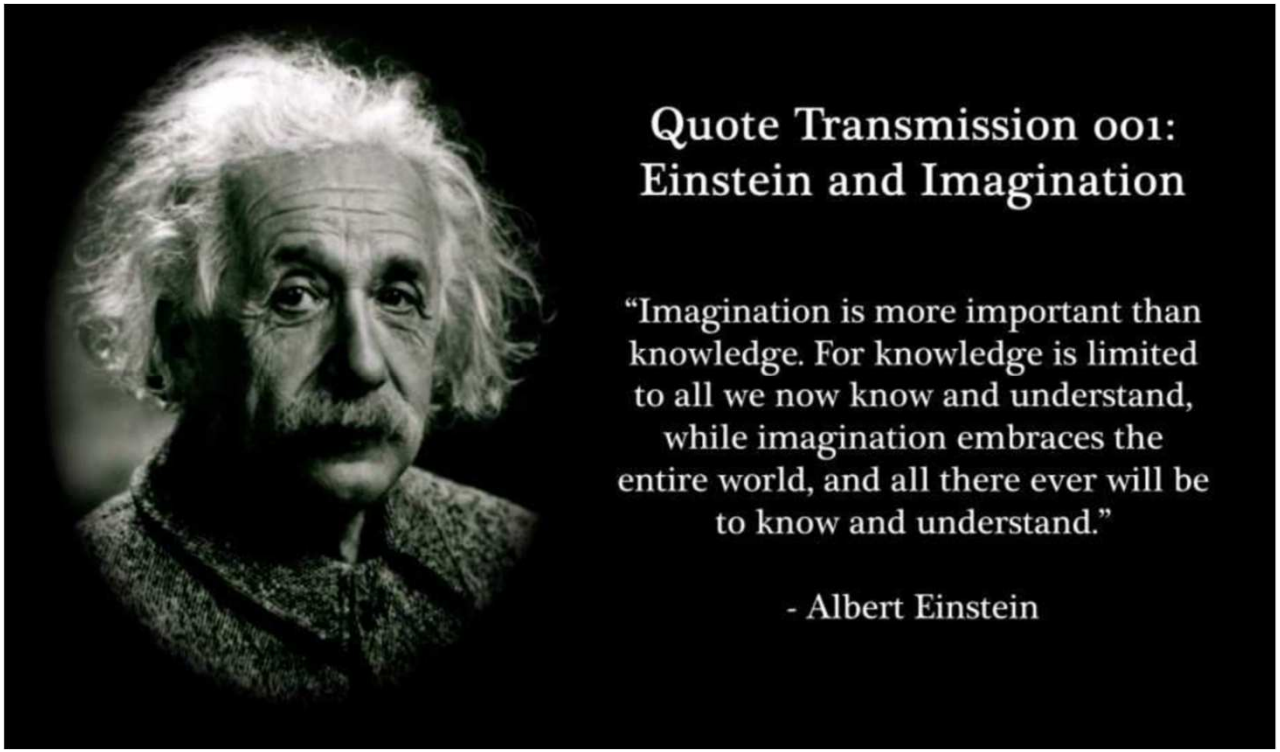
THOUGHT 9

TAKE THE RISK, CROSS THE SECURITY BARRIER, CROSS THE COMFORT ZONE

Multidisciplinarity: bringing novel science fields into riverine management (social sciences,..)

THOUGHT 10

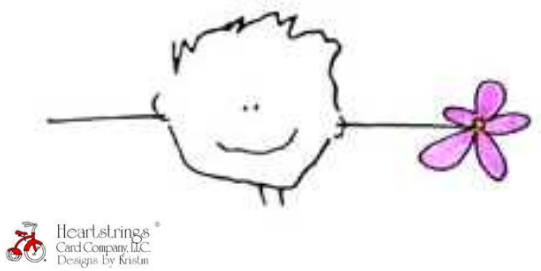
KNOWLEDGE AND IMAGINATION



THOUGHT

YOUR THOUGHTS!

Thanks for listening



Any questions?

fraguiar@isa.ulisboa.pt