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# Effects of exotic forest plantations on functional and structural indicators of stream health in south-central Chile

**Francisco J. Peñas**, Muñoz, E., Gorski, K., Colin, N. & Figueroa, R.

# Background
# Project HANSEL

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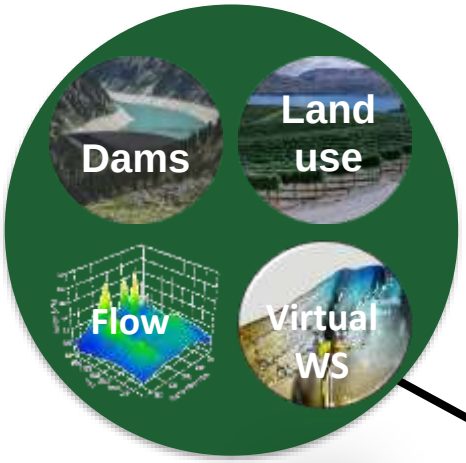
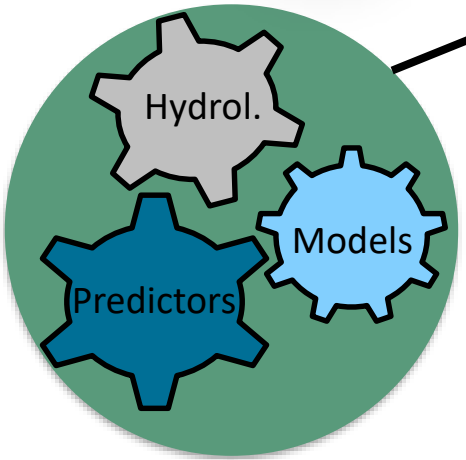
## General project objetive

**Estimate how the hydrological alteration caused by dams and land-use changes compromises the functioning of river systems.**

## Task 1

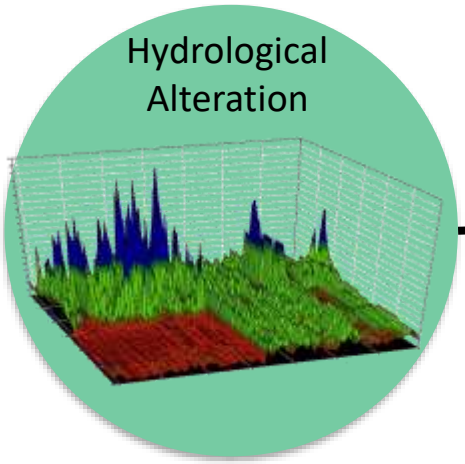



## Task 2



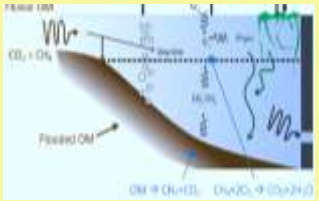

## Task 3

Hydrological Alteration



## Task 4

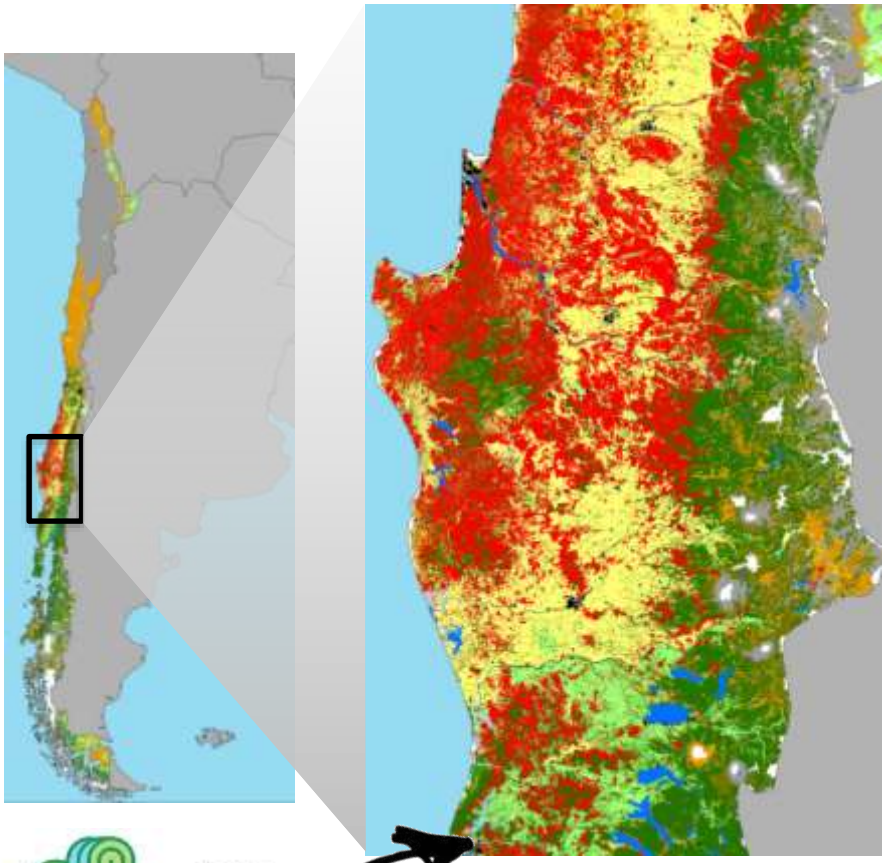
Ecosytem Function & Structure



# Background

**Native forest conversion for forest exotic plantations is dramatic in south-central Chile.**

**GLOBAL LAND-USE CHANGES**



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# Background

## Land-uses changes

Native forest landscape

Exotic plantation landscape

Changes in hydrology, nutrient concentration, physico-chemistry, energy subsides, sediment storage and routing to channels

Biodiversity

Ecosystem Functioning

Ecosystem services

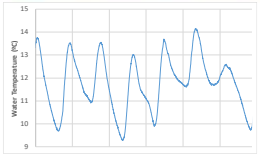
# Background

**How to study the influence the replacement of native forest in river ecosystems?**

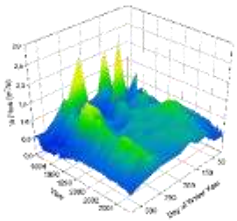
Ecosystem structure

Ecosystem Functioning

**Nutrients**



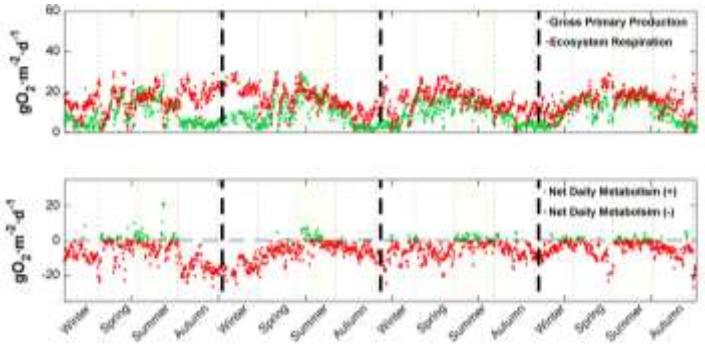
Physico-chemistry



Flow

Biofilm

Biological communities



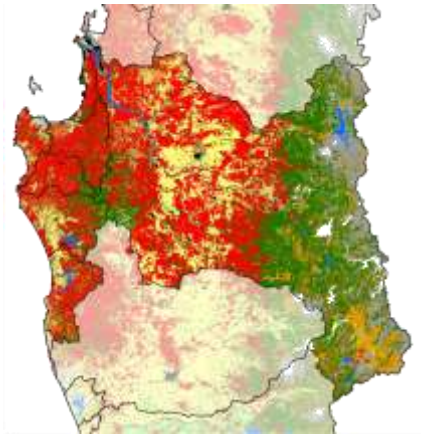

Ecosystem Metabolism

Productivity and Respiration

# Objective

**The main objective of this study is to assess the influence of replacement of native forest by exotic plantations on the structure and functioning of river ecosystems.**

## Study area



# Study design: CONTROL-IMPACT design

**IMPACTS**

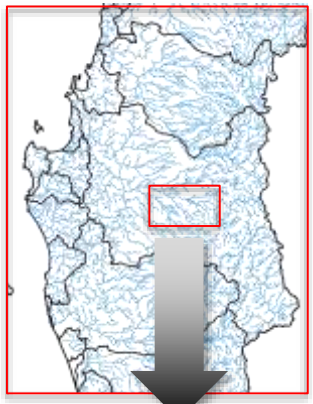
Exotic plantations

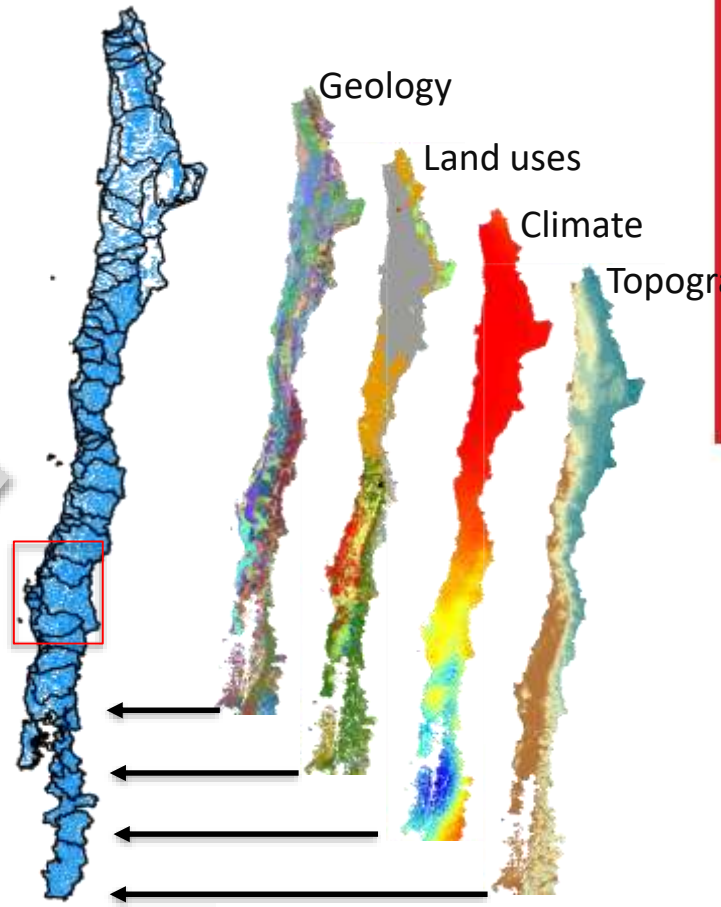
**CONTROLS**

Native forest

## Creating virtual watersheds

FLUVIAL NETWORK






10.215 network segments
17 – 1700 meters length
>20 catchment & local variables

# Methods

## Study design: CONTROL-IMPACT design

**IMPACTS**

Exotic plantations

**CONTROLS**

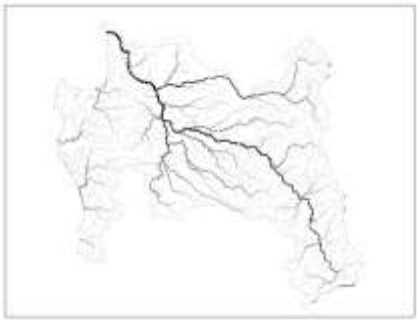
Native forest

**Land-use (%)**

- < 10
- 11% - 20%
- 21% - 30%
- 31% - 40%
- 41% - 50%
- 51% - 60%
- 61% - 70%
- 71% - 80%
- 81% - 90%
- >90%

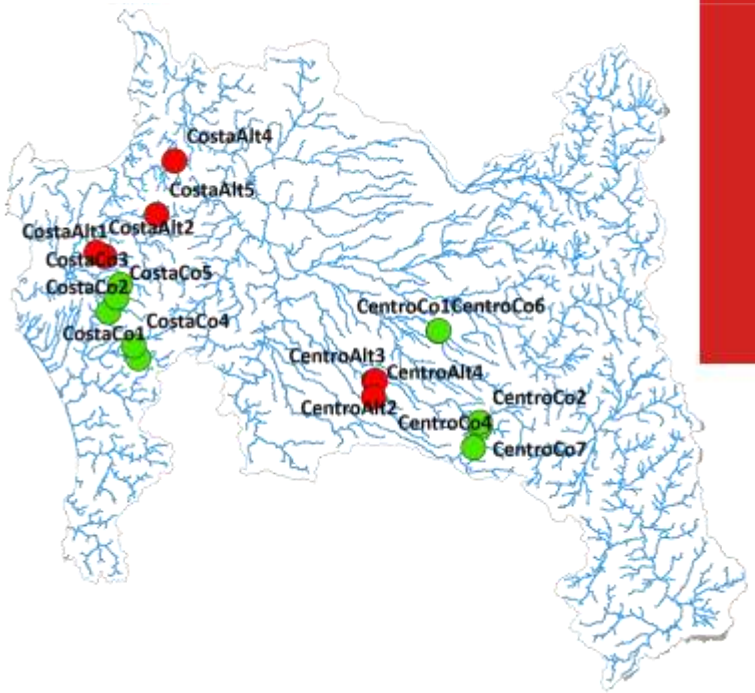
**Hydrological Classification**

- Cl1
- Cl2
- Cl4
- Cl9
- Cl10
- Cl11
- Cl12
- Cl13
- Cl14



**Catchment area ($km^2$)**

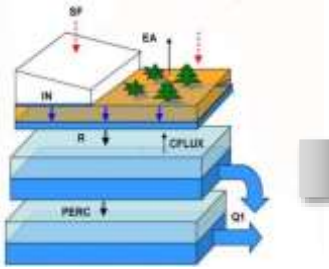
- < 0.15
- 0.15 - 100
- 101 - 200
- 201 - 400
- 401 - 800
- 801 - 1500
- 1501 - 3000
- 3001 - 6000
- 6001 - 12000
- > 12001



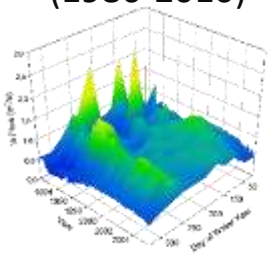
# Hydrological indicators

## Control Sites

**HBV** hydro. model




Flow Series
(1980-2010)



*standarize*

85 Hydrological Indices

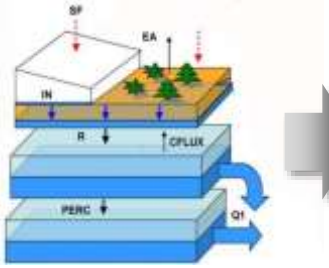
- Magnitude
- Frequency
- Duration
- Timing
- Rate of change

Natural Flow Regime Paradigm

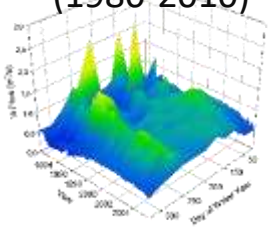
**Mean Reference condition**

## Impacted Sites

**HBV** hydro. model




Flow Series
(1980-2010)



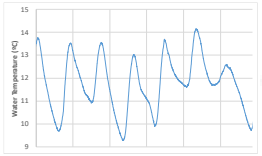
*standarize*

85 Hydrological Indices

% of change in each impacted site respect the control sites

# Structural Indicators

## Water characterization



Water temperature
pH
Electrical Conductivity (EC)
Total Dissolved Solids (TDS)

Total Suspended solid (TDS)


Nitrate
Phosphate

## Biofilm characterization

Chlorophyll A (ChlA)

Ephilitic biomass (EpB; biofilm organic matter)

## Sediment characterization

Sediment size

## Biodiversity

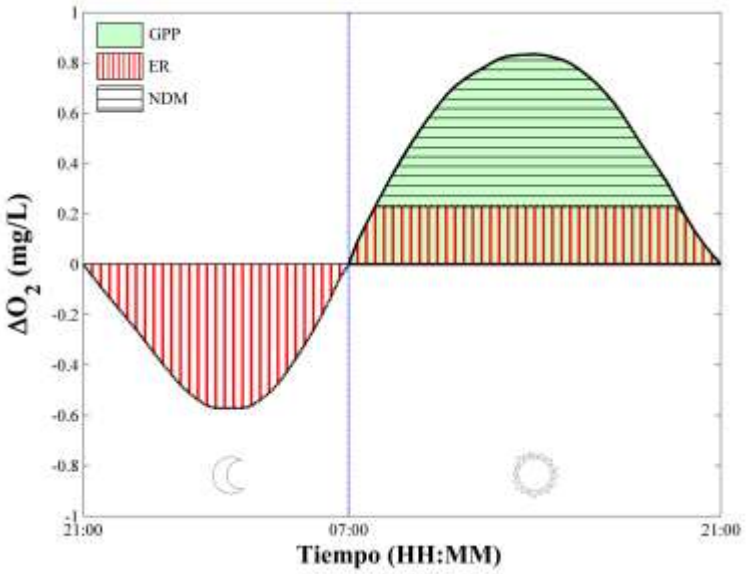
Richness
Diversity
Abundance
EPT (intolerant)
No-Insects (tolerant)

Richness
Abundance
Biomass
Native vs
non-native

# Functional Indicators

**River Metabolism**

ΔDO = Primary Production – Respiration ± Gas Exchange




$$NDM_i = \left[ \frac{DO_i - DO_{i-t}}{t} - K_2 (C_s - DO_{i-t}) \right] D$$

Gas exchange coefficient

DO saturation

1 Dissolved Oxygen (DO) measure each 5 minutes

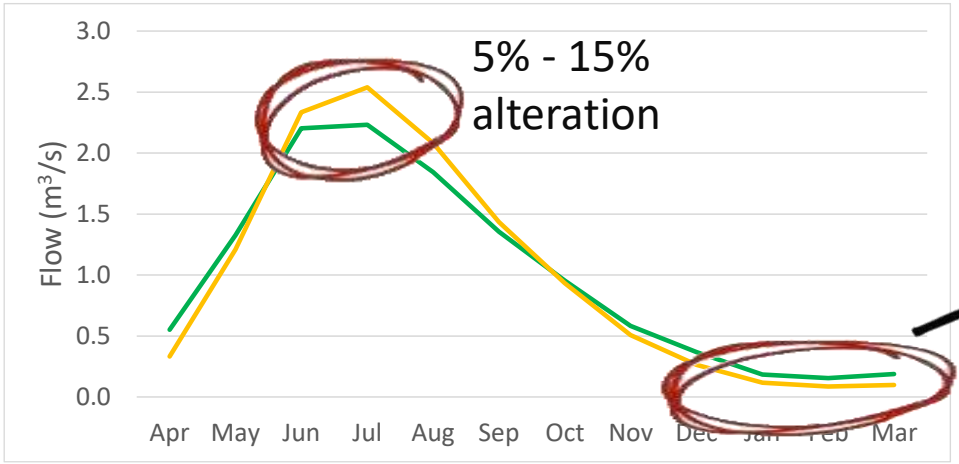
72 Hours

+ Light (sunrise/sunset)

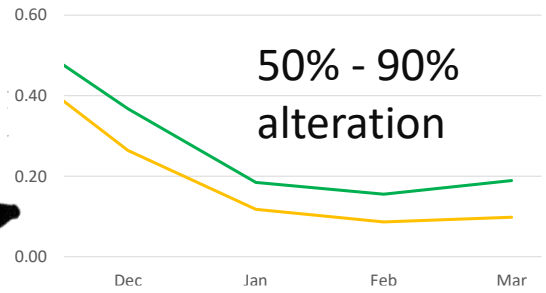
Gross Primary Production (GPP)
Ecosystem Respiration (ER)
Net Daily Metabolism(NDM)

# Hydrological indicators

Alteration of patterns of **low flows**




Major impacts in costal sites



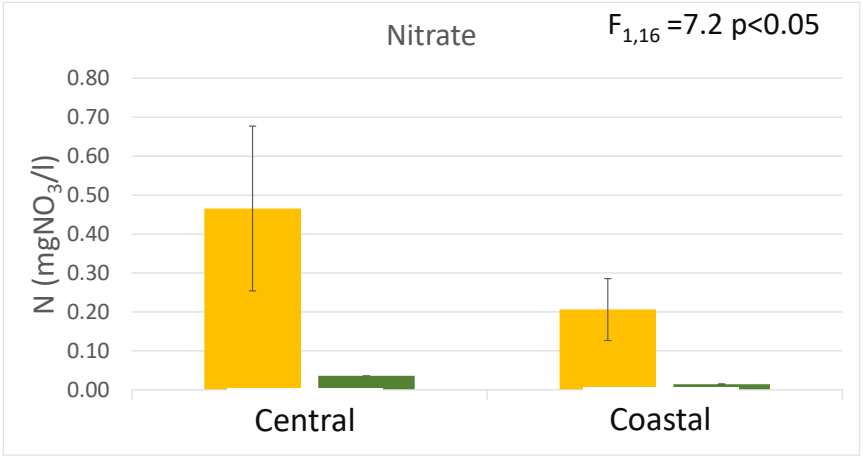

Impact sites — Control sites

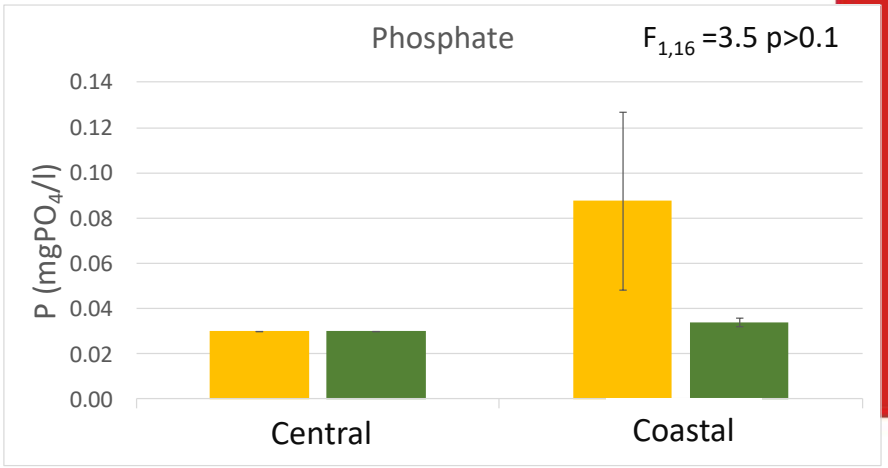
Duration of low flow episode ↑ Central sites ↓ Costal sites

Number of high flows pulses ↓ Central sites ↑ Costal sites

Timing of highest flows ↓ Central sites

# Structural indicators: Water, sediment & biofilm

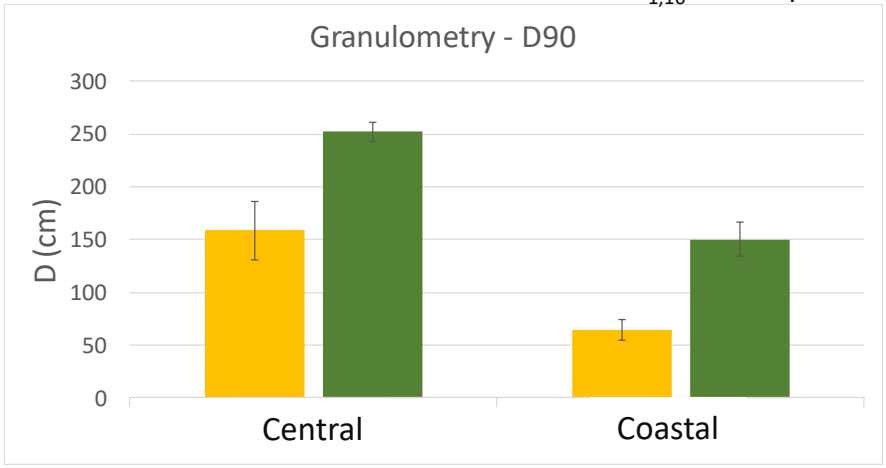


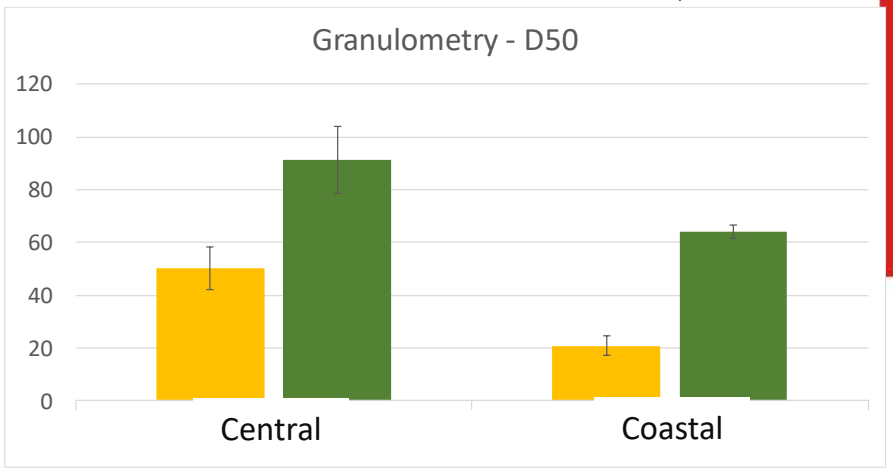

Impact sites  Control sites

# Structural indicators: Water, sediment & biofilm

**Impact** $F_{1,16}$ =25.9 p<0.01
**Zone** $F_{1,16}$ =27.96 p<0.01



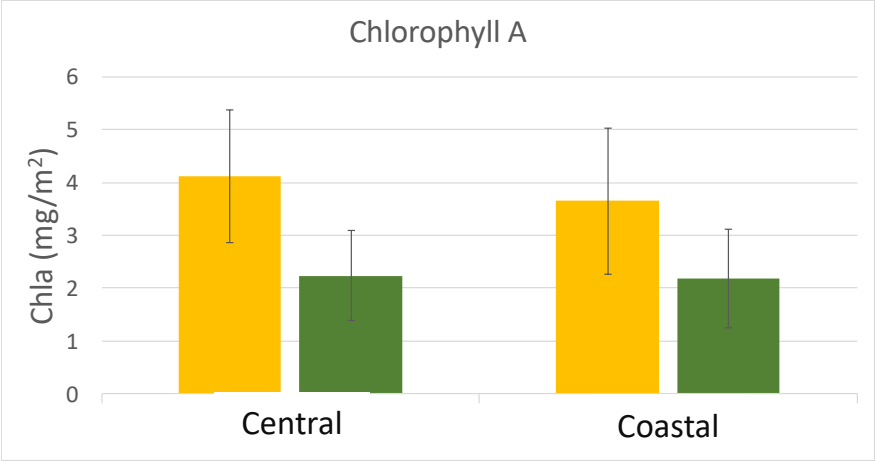

**Impact** $F_{1,16}$ =15.9 p<0.01
**Zone** $F_{1,16}$ =6.5 p<0.05




Impact sites  Control sites

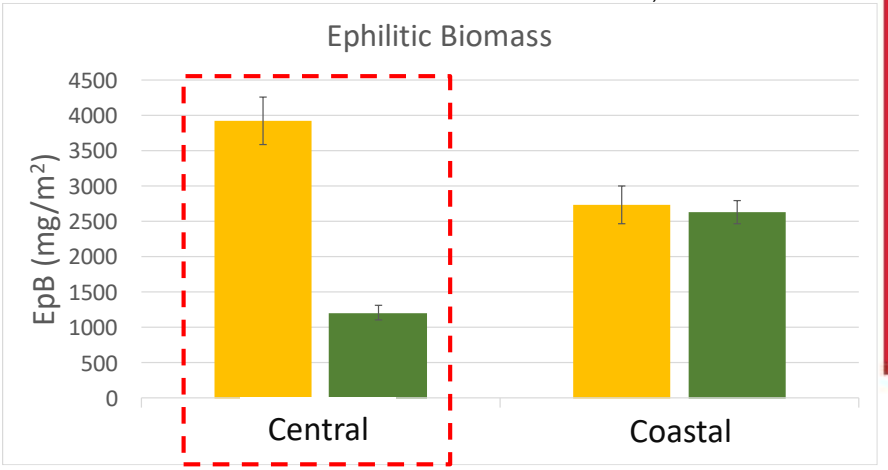
# Structural indicators: Water, sediment & biofilm

$F_{1,17}$ =3.7 p=0.10




**Impact** $F_{1,17}$ =23.6 p<0.01

**Interaction** $F_{1,17}$ =22.34 p<0.01




$F_{1,6}$ =39.4 p<0.01

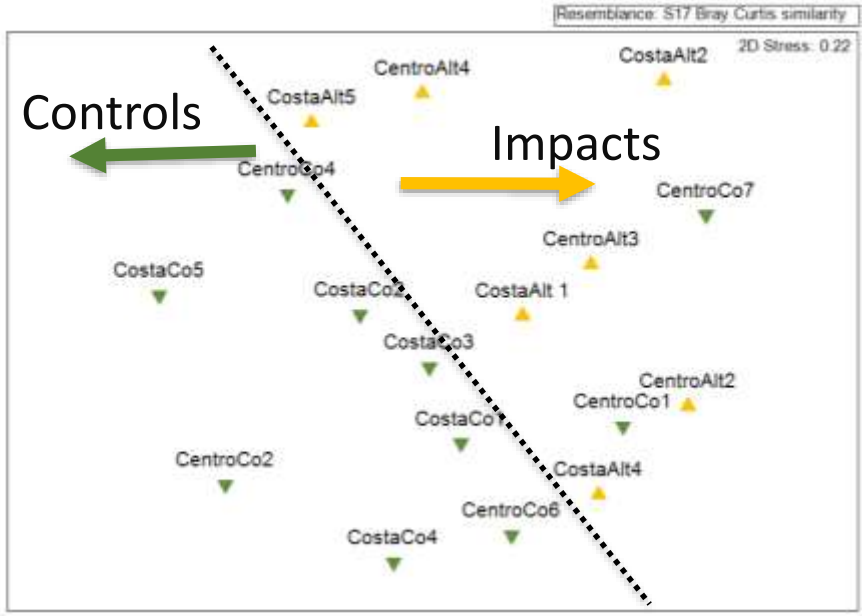
$F_{1,7}$ =1.05 p>0.05

Impact sites Control sites

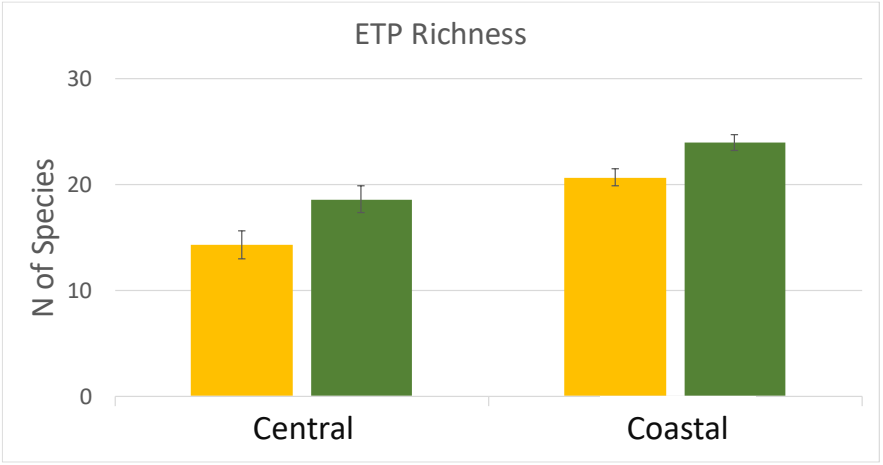
# Results

## Structural indicators:

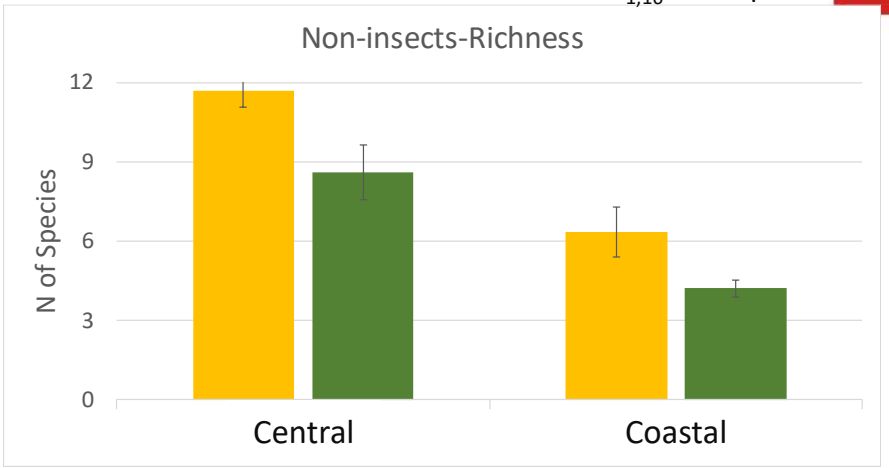
### Biological (invertebrates)




**Impact** $F_{1,16}$ =6.57 p<0.05
**Zone** $F_{1,16}$ =20.9 p<0.01

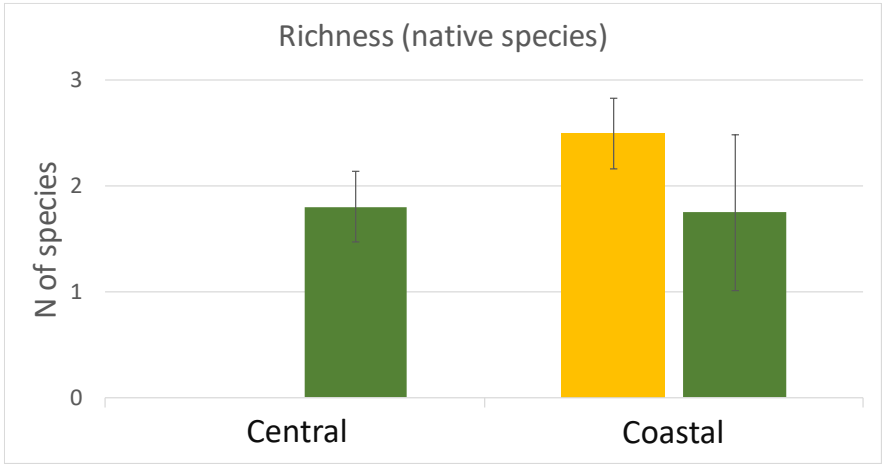


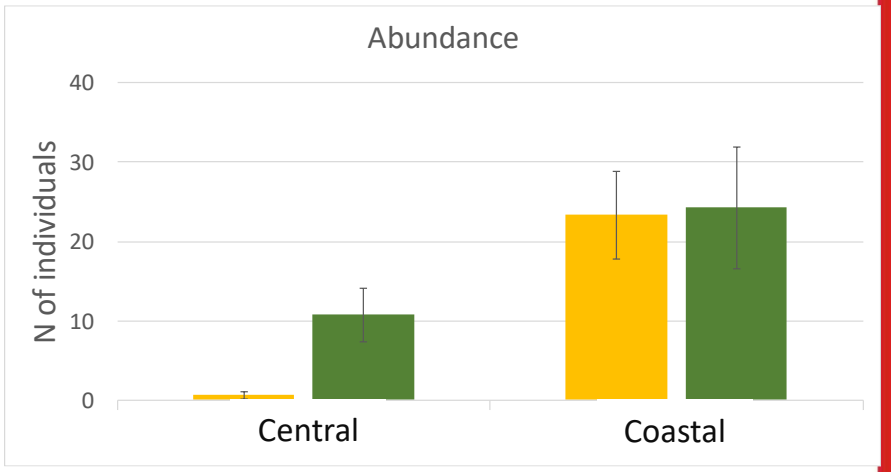

**Impact** $F_{1,16}$ =7.4 p<0.01
**Zone** $F_{1,16}$ =22.8 p<0.01

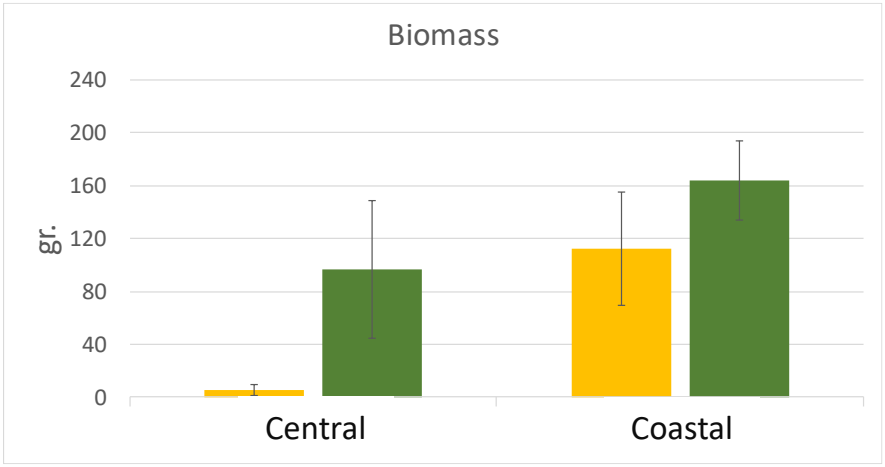



Impact sites  Control sites

# Structural indicators: Biological (fishes)



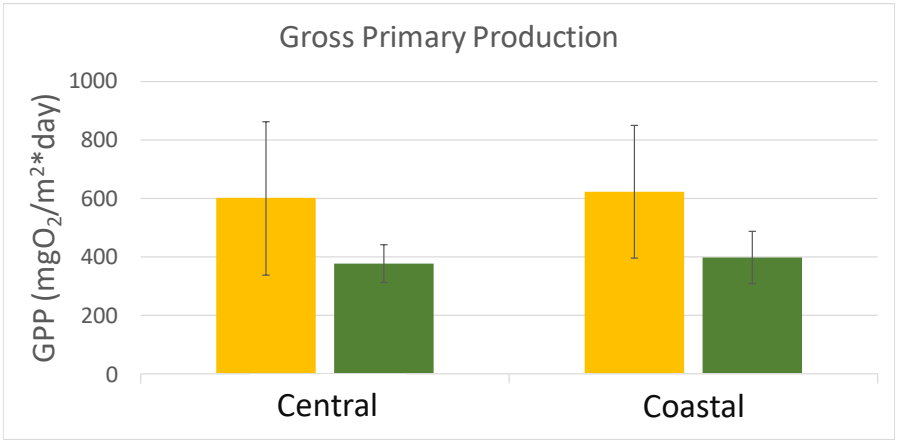



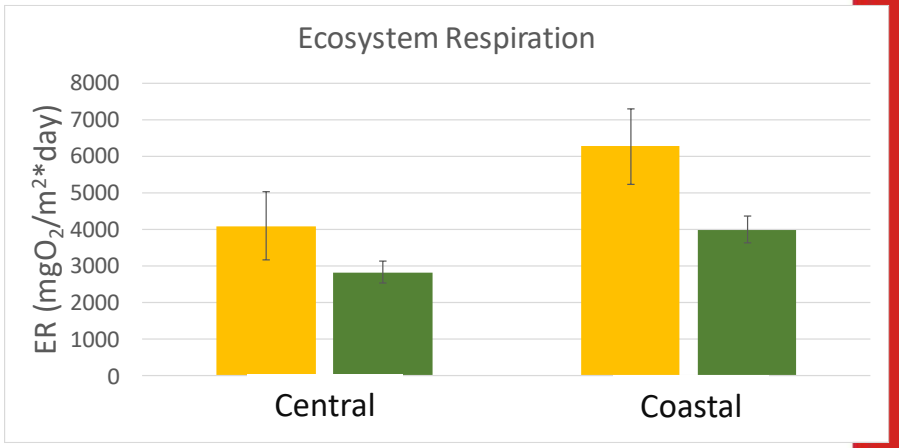

Impact sites Control sites

# Functional indicators: Ecosystem Metabolism

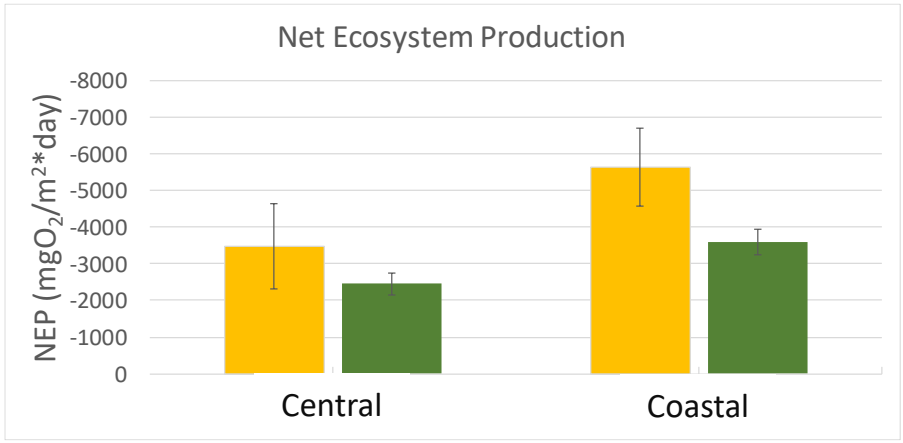
$F_{1,16}$ =0.48 p=0.49




$F_{1,16}$ =6.1 p<0.05




$F_{1,17}$ =4.4 p<0.05




Impact sites  Control sites

# Conclusions

- Patterns of low flows were highly altered in the catchments dominated by forest plantations, where reductions over 50% were observed for the summer flows

- Substrate size, conductivity and invertebrate communities showed clear differences among control and impact sites while some other structural indicators, such as epilithic biomass or fish communities, differed their behaviour according to location.

- River ecosystem metabolism provided consistent results and can be considered a good indicator to measure the effect of forest replacement in rivers. Changes might be related with an accelerated functioning of basal trophic levels and higher rates of consumption of allochthonous material.

- Results of this study are promising to provide cause-effects relationships between structural and functional indicators to better understand how forest plantations affect river ecosystems. However, additional samples to be collected in coming months are expected to test significance of these results.

# Thanks for your attention!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-

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