EDF | OFB Office Français de la Biodiversité | INRAE | hepia Haute école du paysage, d'ingénierie et d'architecture de Genève

Multidecadal trends in brown trout (*Salmo trutta*) populations, in regulated and unregulated rivers

L. Tissot , V. Gouraud, N. Poulet, H. Capra, F. Cattanéo and A. Maire

Conference Sustainability in Hydropower 2023

CONTEXT

- 37% of freshwater fish species are threatened in Europe, and about 17% have declining populations
- Multiple causes contribute to this decline (habitat degradation, species invasion, water pollution or overfishing), all interplaying with climate change

BIOLOGICAL REVIEWS — Cambridge Philosophical Society

Original Article | Free Access

Emerging threats and persistent conservation challenges for freshwater biodiversity

Andrea J. Reid, Andrew K. Carlson, Irena F. Creed, Erika J. Eliason, Peter A. Gell, Pieter T. J. Johnson, Karen A. Kidd, Tyson J. MacCormack, Julian D. Olden, Steve J. Ormerod, John P. Smol ... See all authors

First published: 22 November 2018 | https://doi.org/10.1111/brv.12480 | Citations: 1,180

REVIEW SUMMARY

CLIMATE CHANGE

The broad footprint of climate change from genes to biomes to people

Brett R. Scheffers,* Luc De Meester, Tom C. L. Bridge, Ary A. Hoffmann, John M. Pandolfi, Richard T. Corlett, Stuart H. M. Butchart, Paul Pearce-Kelly, Kit M. Kovacs, David Dudgeon, Michela Pacifici, Carlo Rondinini, Wendy B. Foden, Tara G. Martin, Camilo Mora, David Bickford, James E. M. Watson

Ongoing global change: effects already observed on aquatic communities

Freshwater Biology

ORIGINAL ARTICLE | Open Access

Poleward shift in large-river fish communities detected with a novel meta-analysis framework

Anthony Maire, Eva Thierry, Wolfgang Viechtbauer, Martin Daufresne

First published: 22 March 2019 | https://doi.org/10.1111/fwb.13291 | Citations: 27

ELSEVIER — Science of The Total Environment
Volume 703, 10 February 2020, 134523

Effects of multiple stressors on the distribution of fish communities in 203 headwater streams of Rhine, Elbe and Danube

Melanie Mueller [1], Antje M. Bierschenk [1], Beate M. Bierschenk [1], Joachim Pander, Juergen Geist

JOURNAL OF FISH BIOLOGY — fsbi

Token Access

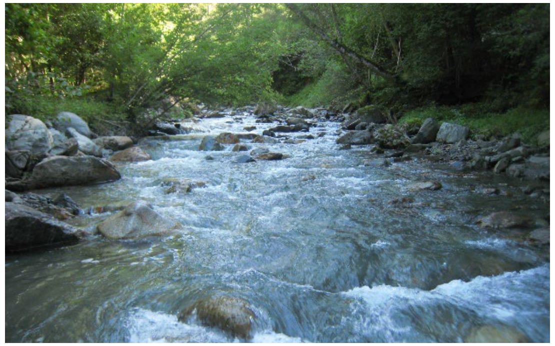
Time trends in fish populations in metropolitan France: insights from national monitoring data

N. Poulet, L. Beaulaton, S. Dembski

First published: 09 September 2011 | https://doi.org/10.1111/j.1095-8649.2011.03084.x | Citations: 71

CONTEXT

- Headwater streams constitute most of the length of hydrographic networks
- In France, they are mostly salmonid streams, where the brown trout (*Salmo trutta*) is the dominant species
- 80% of French hydroelectricity powerplants are in headwater streams



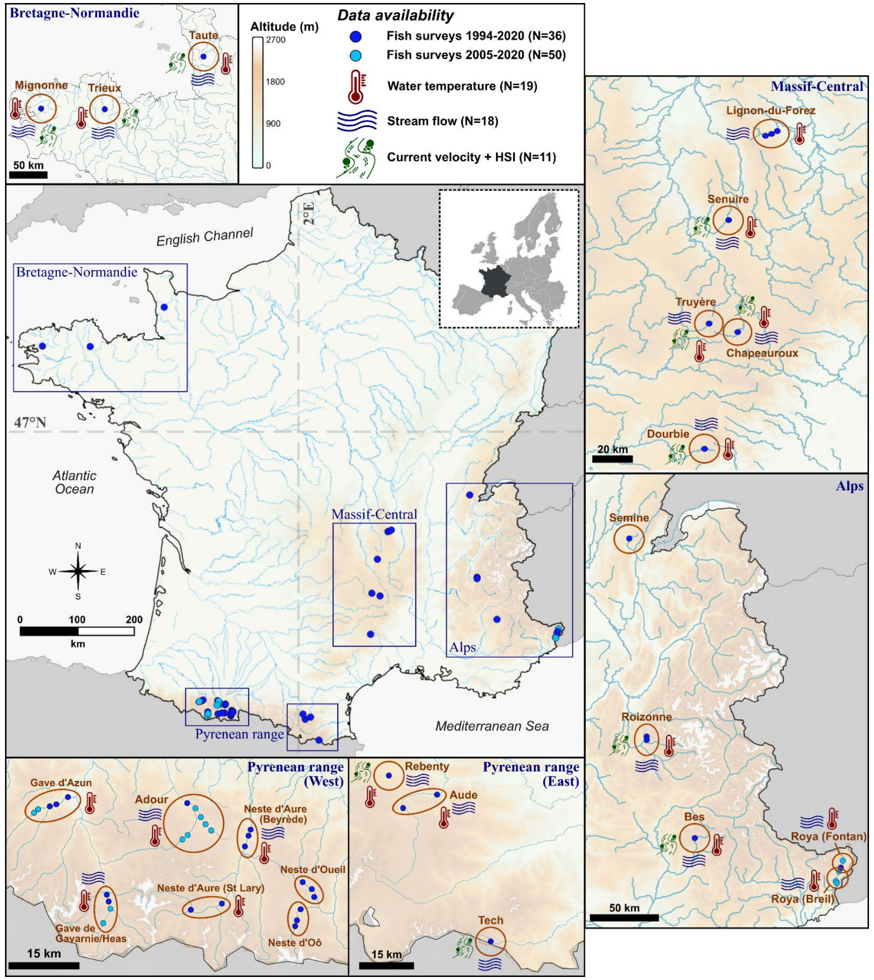
But few studies have focused on long term trends of trout population densities, while including the effect of the presence of hydroelectric powerplants

OBJECTIVE AND SCOPE OF THE STUDY

OBJECTIVE: Identify the observed trends in trout population densities and key environmental drivers in French headwater steams

DATA: Monitoring of regulated (subject to a minimum instream flow) and unregulated stream reaches

- ✓ Stream-dwelling brown trout (*Salmo trutta*) populations, spanning a diversity of French geographic areas (lowland and mountain streams)
- ✓ Environmental variables known as drivers of trout population dynamics (water temperature, stream flow, current velocity and habitat suitability)



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DATA → TIMES SERIES 1990-2020

TROUT DATA

- 36 stream reaches (≈ 100 m length ; ≈ 8 m width), subject to a minimum instream flow (BPS) or without hydrological modification (NHM)

Nb	BPS	NHM	Total
ALP	2	3	**5**
BN	0	3	**3**
MC	2	5	**7**
PYR	15	6	**21**
Total	**19**	**17**	**36**

- Two-pass removal electrofishing sampling
- 13-27 fish samplings on each reach over 1994-2020
- Trout population distinguished in 3 cohorts: young-of-the-year (YoY or 0+), juveniles (1+) and adults (>1+)

ENVIRONNEMENTAL DATA

- Number of reaches
  - ✓ Water temperature: 19
  - ✓ Stream flow: 18
  - ✓ Flow velocity: 11
  - ✓ Habitat Suitability Index (HSI): 11

- Metrics: median, 10-percentile and 90-percentile values
- Metrics scale: annual + 4 seasons
  - ✓ Spring (March-May)
  - ✓ Summer (June-August)
  - ✓ Fall (Sept-Nov)
  - ✓ Winter (Dec-Feb)

⇨ 75 synthetic metrics

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STATISTICAL METHOD

General temporal trends in environmental variables and densities of 3 trout cohorts were assessed using a meta-analysis framework (Maire *et al.* 2019)

- ✓ Weighted meta-analysis was performed on each environmental and trout variable using Mann-Kendall trend statistics and computed on each time series as "effect sizes"
- ✓ Method is used to statistically assess if there is a general monotonic upward or downward trend in the variable over time, without this necessarily being linear
- ✓ This approach does not allow to quantify the role of each environmental variable, nor the relative share of their effect on trout density trends


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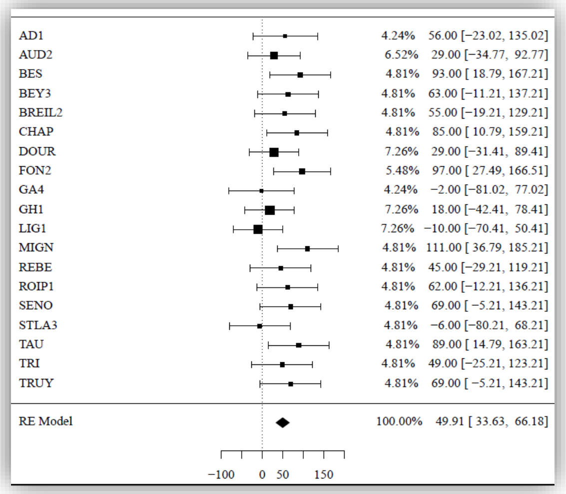

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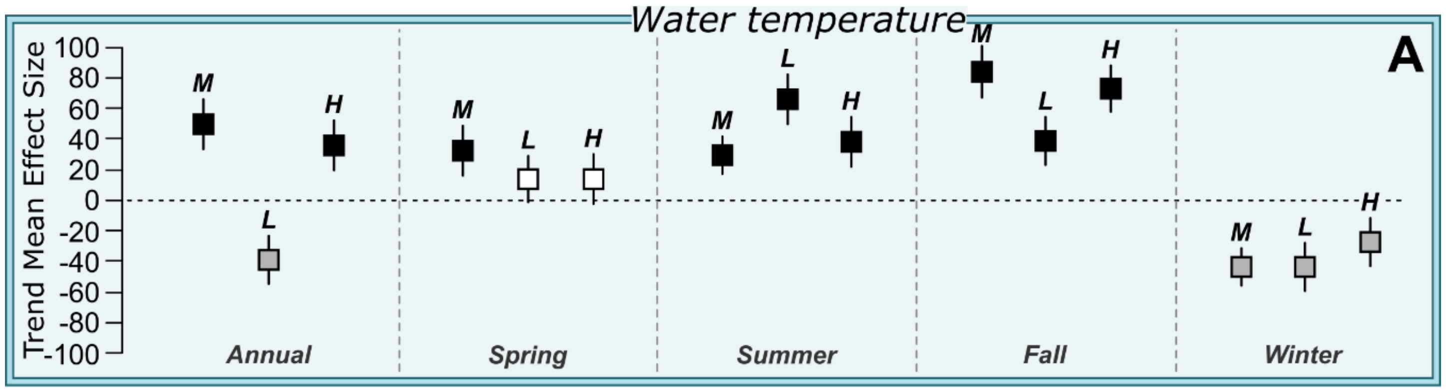
RESULTS FOR WATER TEMPERATURE

- **19 reaches - 15 metrics - period 1990-2015**



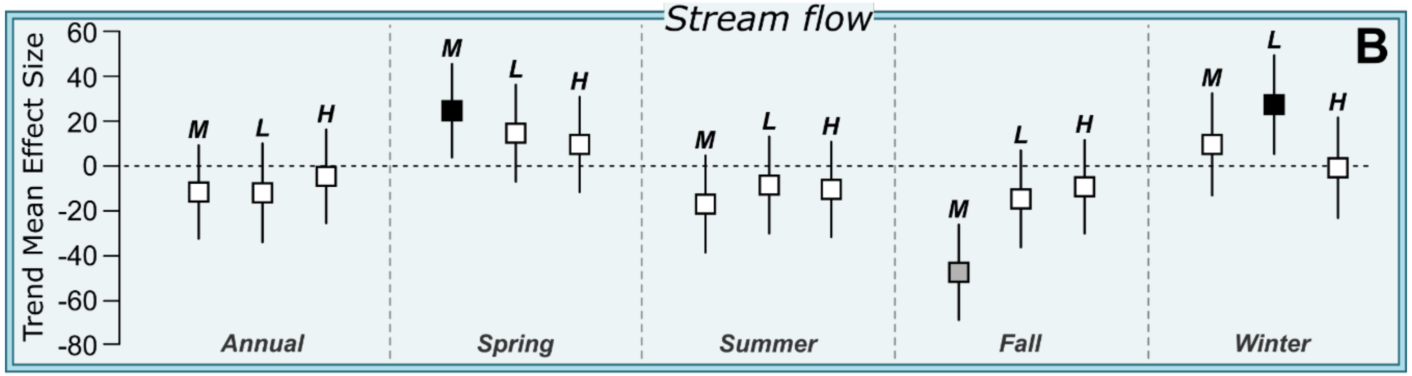
Trend Mean Effect Size **reveals the strength and the sign of the general trend**
M = Median ; L = 10-percentile "trend in low values" ; H = 90-percentile "trend in high values"
■ Significant upward trend ; ■ Significant downward trend ; □ Non-significant trend

- Annual scale : significant upward trend in median and high temperatures / significant downward trend in low temperatures

- Seasonal variability : significant upward trend in water temperature during summer and fall and significant downward trend in winter

RESULTS FOR STREAM FLOW

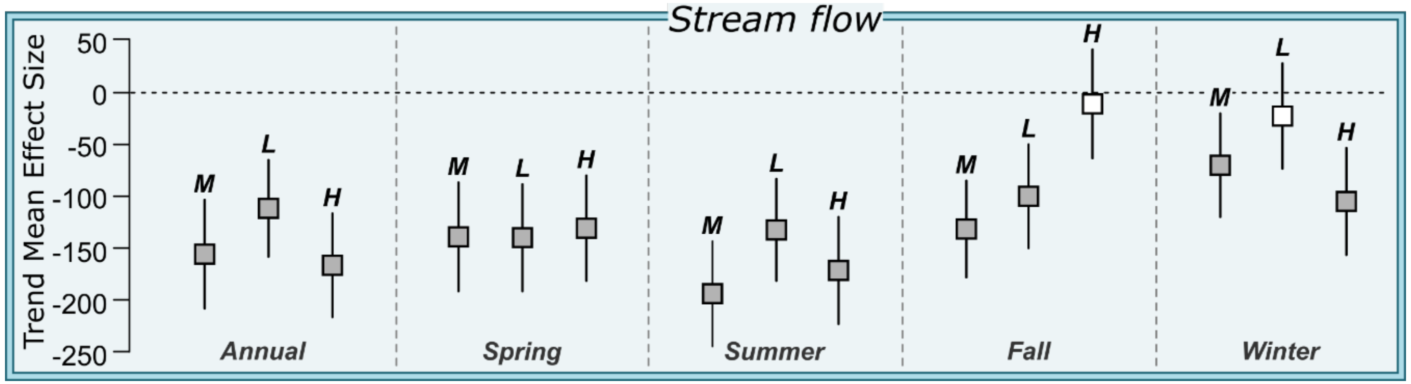
- **18 reaches - 15 metrics - period 1990-2017**



- Few significant trends

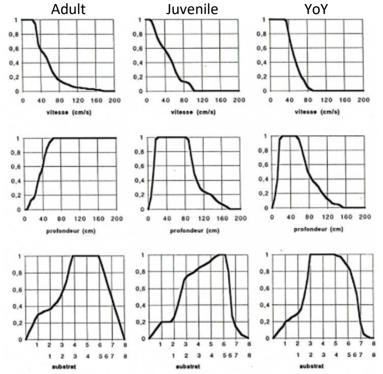
***Trend Mean Effect Size* reveals the strength and the sign of the general trend**
M = Median ; L = 10-percentile “trend in low values” ; H = 90-percentile “trend in high values”
■ Significant upward trend ; ■ Significant downward trend ; □ Non-significant trend

- But significant marked decreasing trends over the extended period 1970-2017

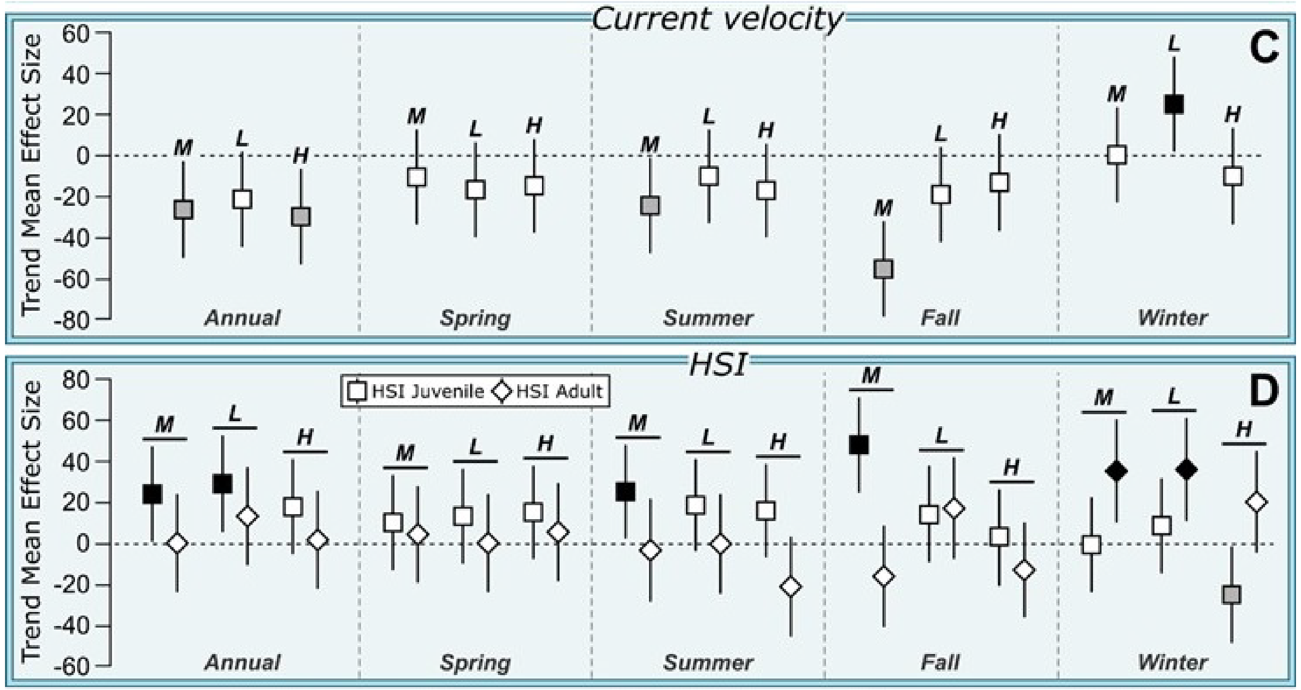


11 reaches

RESULTS FOR FLOW VELOCITY AND HSI



- 11 reaches - 15 metrics - period 1990-2013



Trend Mean Effect Size reveals the strength and the sign of the general trend
M = Median ; L = 10-percentile “trend in low values” ; H = 90-percentile “trend in high values”
■ Significant upward trend ; ■ Significant downward trend ; □ Non-significant trend

- Significant downward trends in flow velocity, more marked than in stream flow
- Significant upward trends for juvenile HSI

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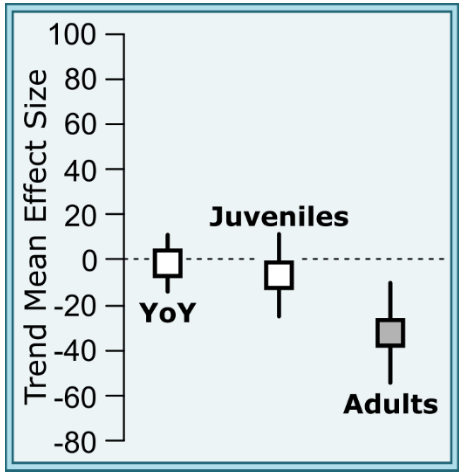
RESULTS FOR TROUT POPULATIONS

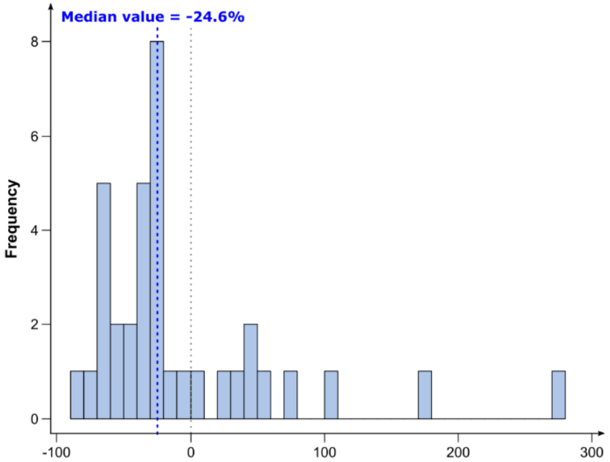
- **36 reaches - 3 metrics - period 1994-2020**



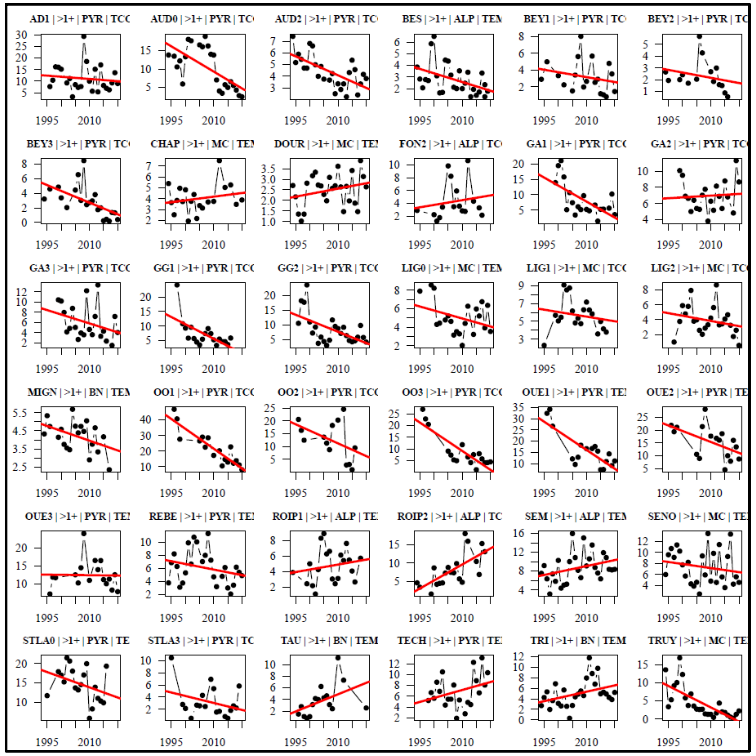
Trend Mean Effect Size **reveals the strength and the sign of the general trend**

■ **Significant trend ; □ Non-significant trend**

- All reaches: significant downward trend for adults, non-significant trends for YoY and juveniles



Change in the adult trout density (%) between the first 5 and last 5 years of each survey



- Geographic variability: significant differences in trends between areas for adults and juveniles
- BPS/NHM variability: non-significant differences in trends between BPS and NHM for the 3 cohorts

Nb	BPS	NHM	Total
ALP	2	3	**5**
BN	0	3	**3**
MC	2	5	**7**
PYR	15	6	**21**
Total	**19**	**17**	**36**

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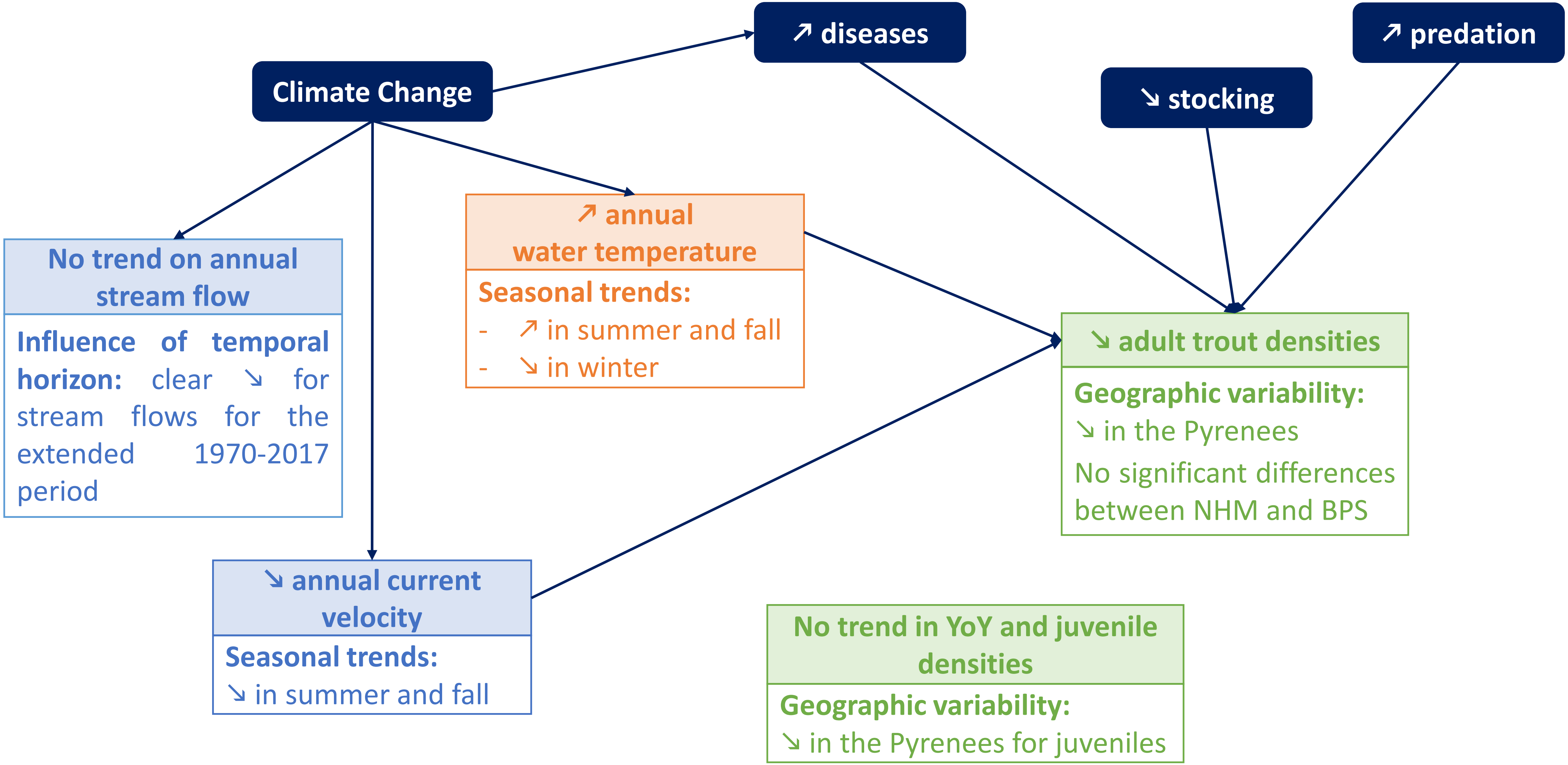
DISCUSSION

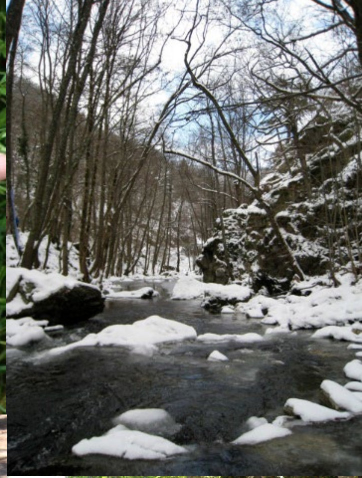

Climate Change
↗ diseases
↘ stocking
↗ predation
No trend on annual stream flow
Influence of temporal horizon: clear ↘ for stream flows for the extended 1970-2017 period
↗ annual water temperature
Seasonal trends:
- ↗ in summer and fall
- ↘ in winter
↘ annual current velocity
Seasonal trends:
↘ in summer and fall
↘ adult trout densities
Geographic variability:
↘ in the Pyrenees
No significant differences between NHM and BPS
No trend in YoY and juvenile densities
Geographic variability:
↘ in the Pyrenees for juveniles

CONCLUSION

- Decline in adult trout densities is likely due to multifactorial effects, including possible interacting factors
- Our approach does not allow to quantify the role of each factors, nor the relative share of their effect on trout density trends
- Need further studies to identify precisely the causes of the adult trout decline and the disparities between areas
- Need to maintain long-term fish monitoring, combined with extensive environmental monitoring to allow appropriate and efficient management measures






Thank you for your attention