

# Nature-based solutions to restore amphibian communities in inland waters

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# Main threats to biodiversity

- changes in land and sea use;
- direct exploitation of organisms;
- climate change;
- pollution; and
- invasion of alien species

Intergovernmental Science Policy Platform on Biodiversity and Ecosystem Services (IPBES, 2019)



**The Pyrenees:  
Amphibian restoration through  
exotic fish removal**

# Pyrenean lake district

1100 lakes >0.5ha  
2000-2500 m.a.s.l.

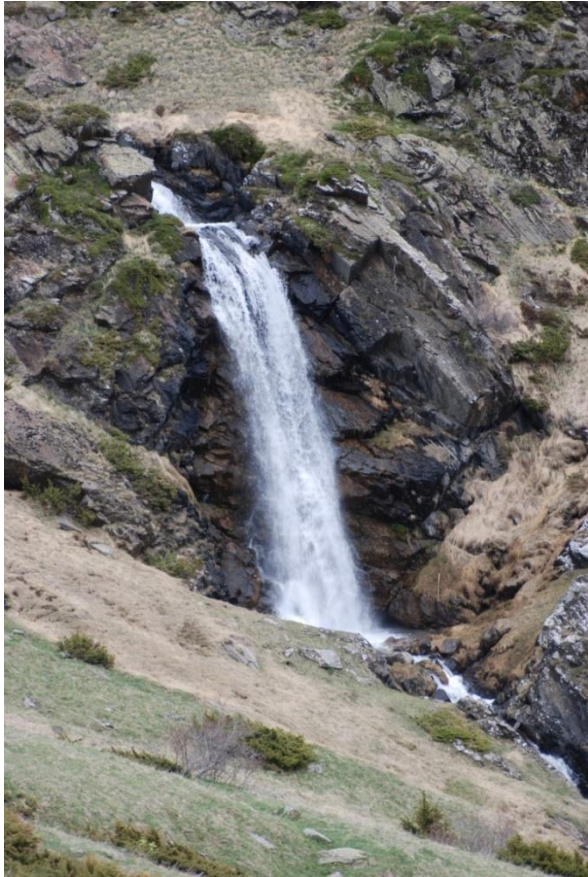


## High mountain lakes and ponds



# Fishless ecosystems

Hydrological barriers downstream in the outflow



Waterfalls



Rockfalls and scree slopes

# Heavily stocked

Pack animals and milk churns

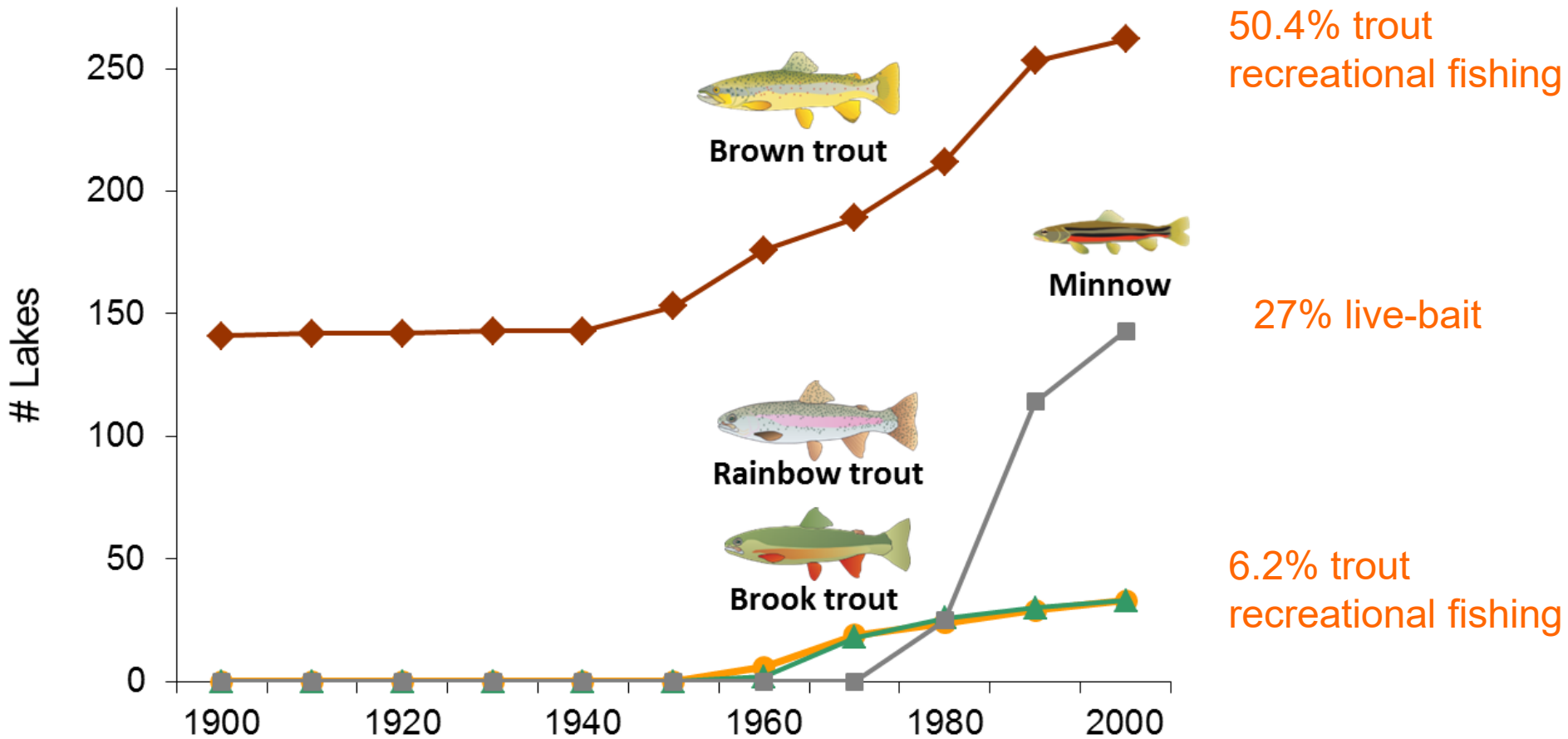


Sant Maurici National Park,  
circa 1980



Cauterets, circa 1970

# Stocking process



# Amphibian assemblage



**Calotriton asper**



**Lissotriton helveticus**



**Salamandra salamandra**



**Rana temporaria**

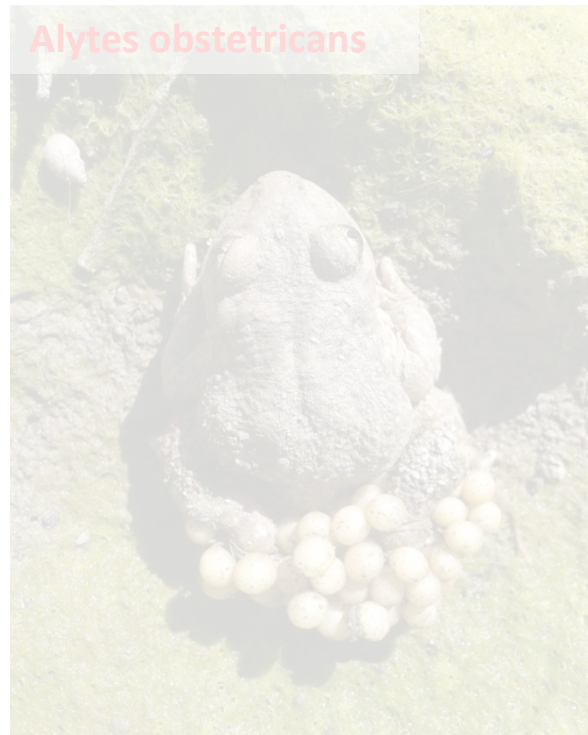


**Alytes obstetricans**

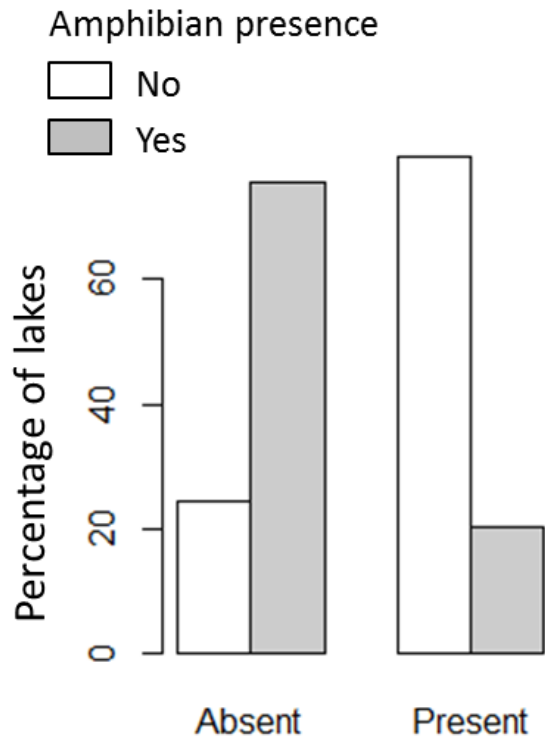


**Bufo spinosus**

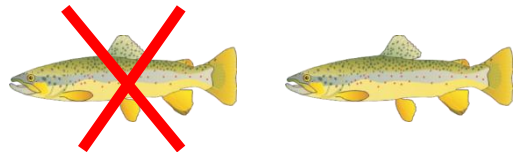
# Amphibian assemblage



# Impact



Introduced fish

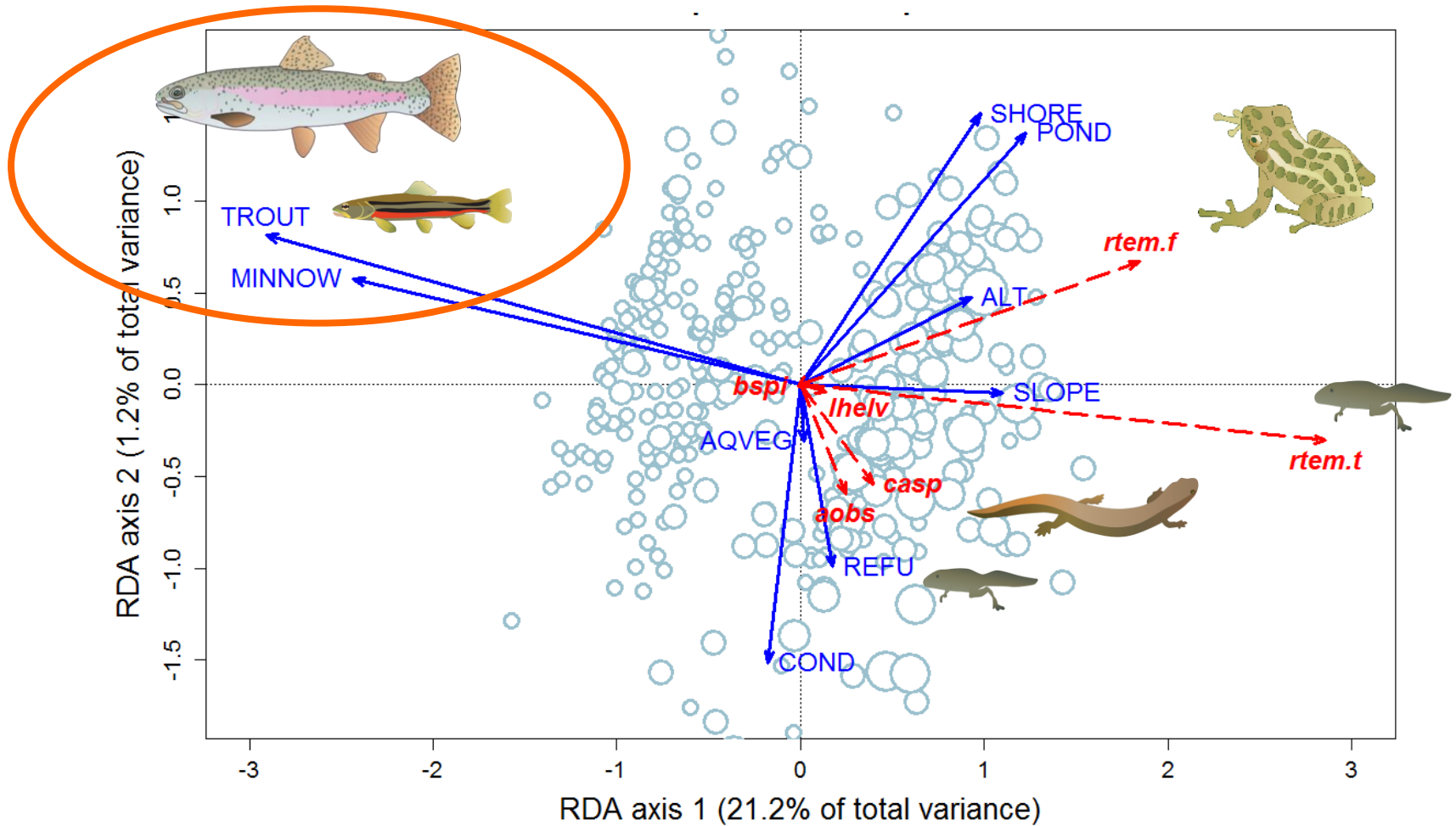


Predation refuge

# Impact

## Redundancy analysis

388 lakes >0.5ha



# Nature restoration



LIFE13 NAT/ES/001210



# Exotic fish removing



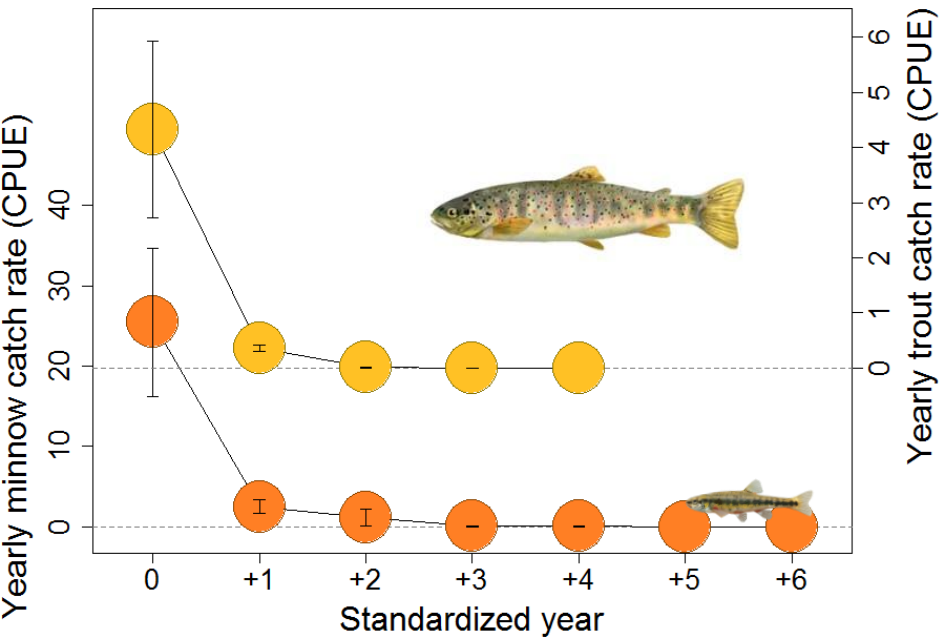
# Restoration effects



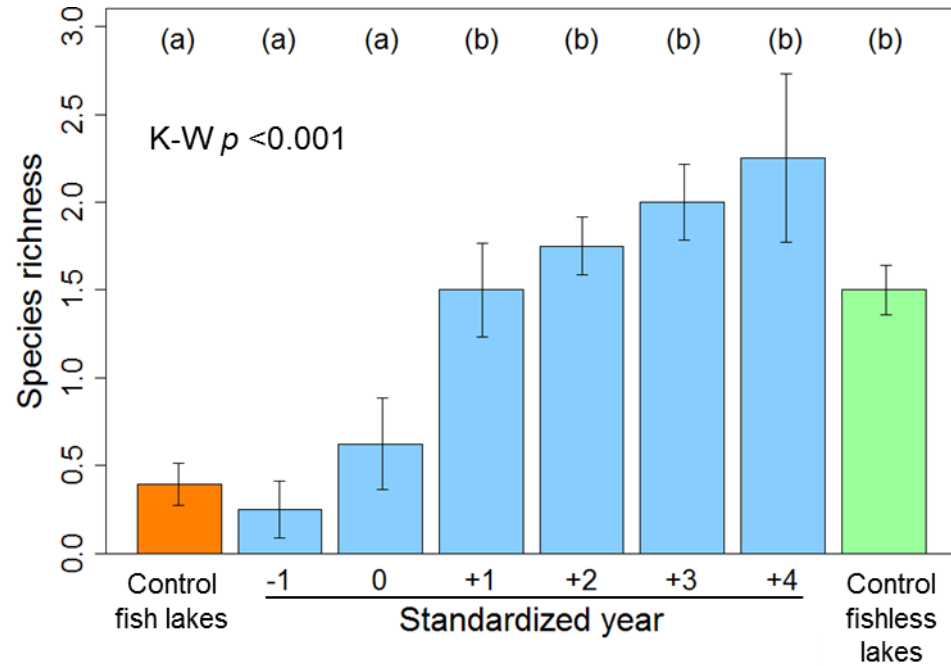
# Restoration effects



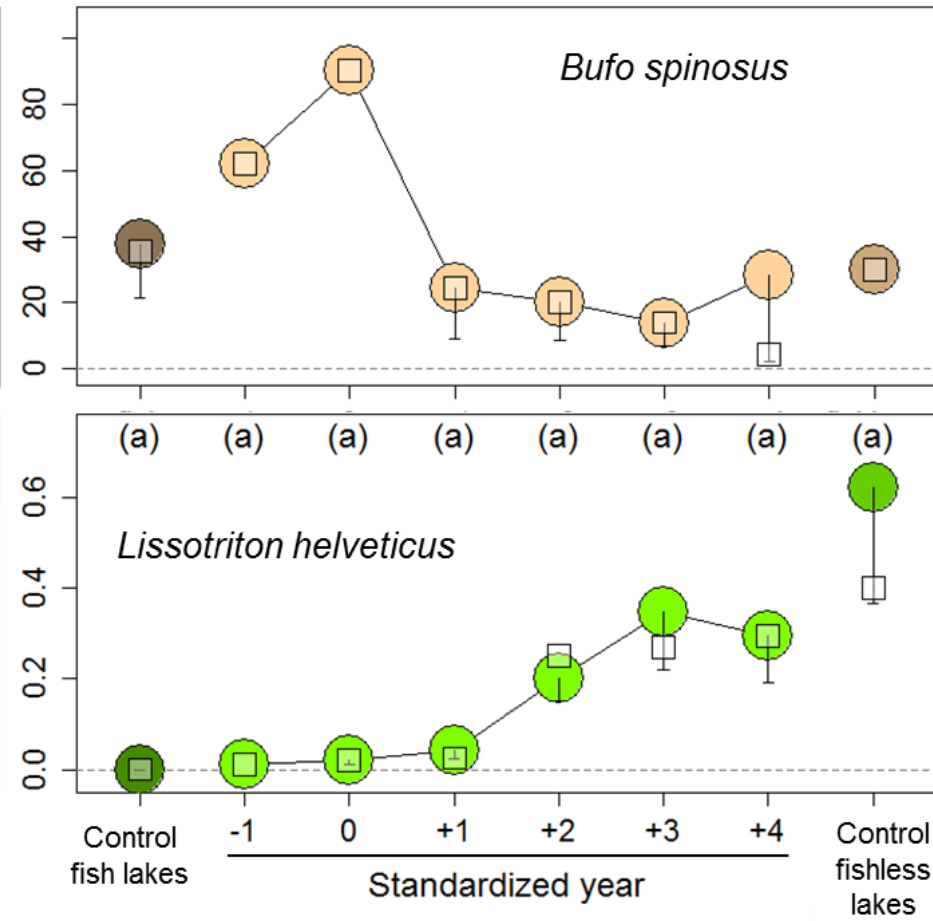
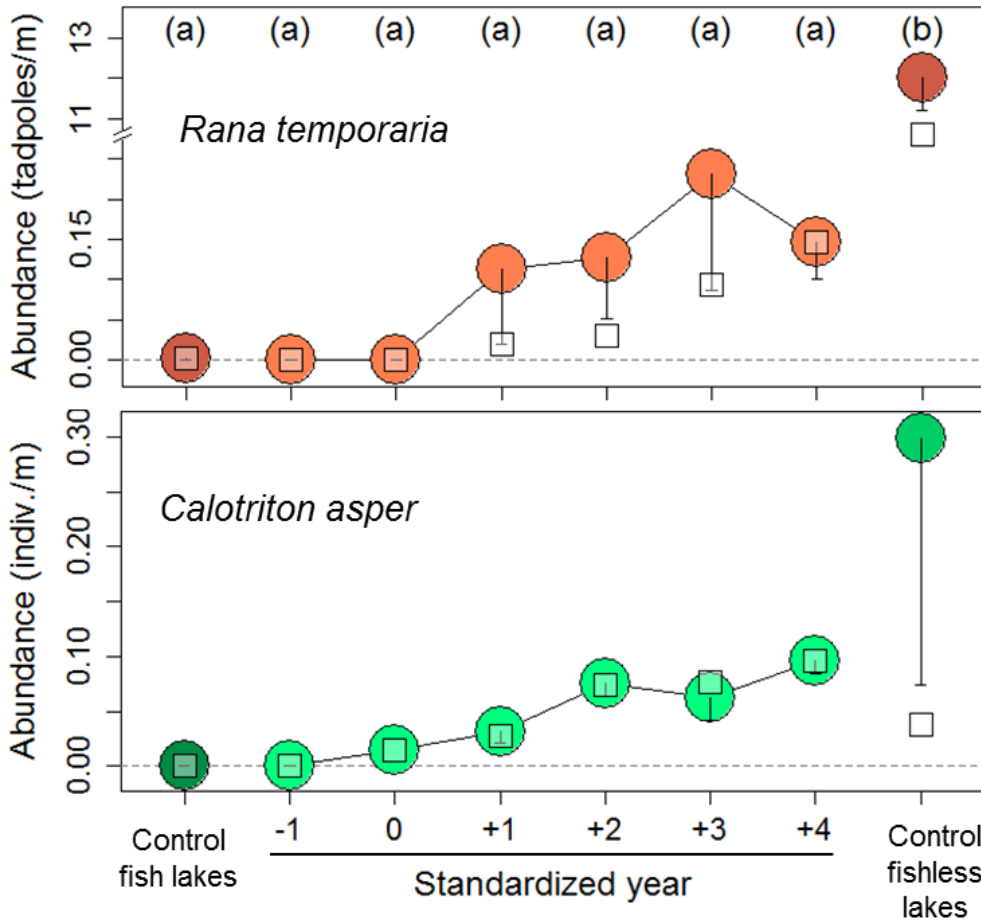
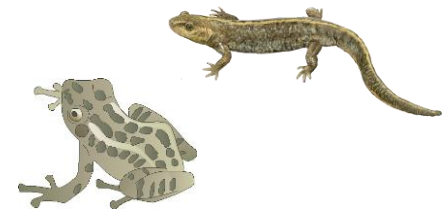
## Non-native fish catches



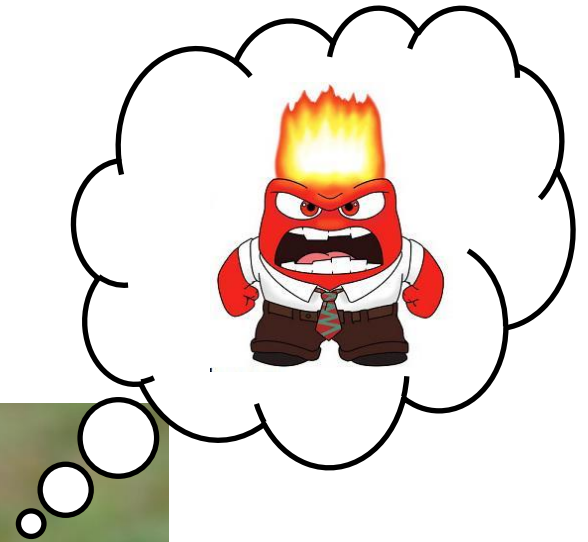
## Amphibian taxonomic richness



# Restoration effects



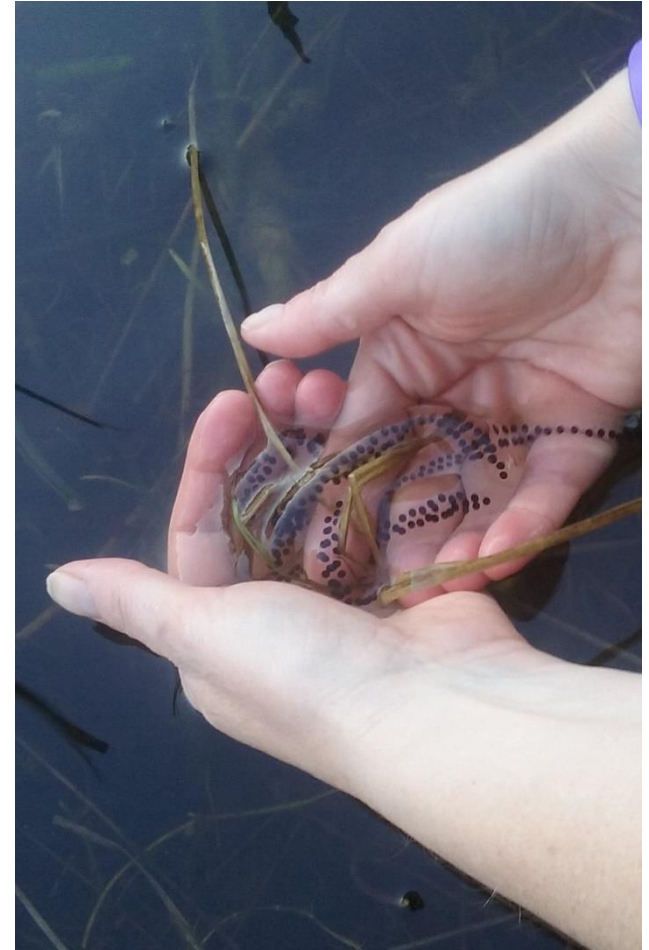
**We love you really**



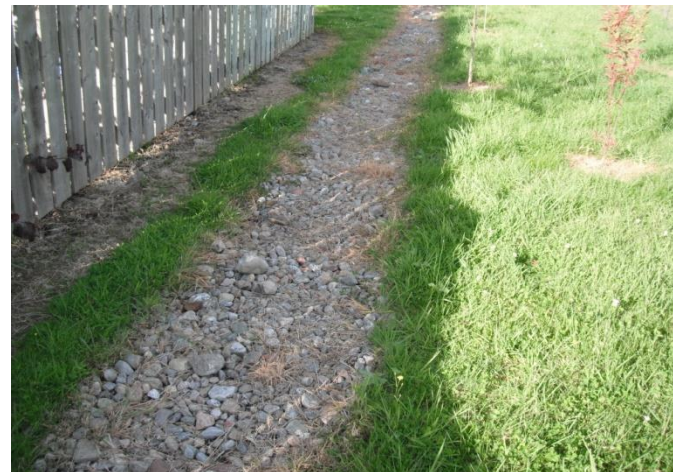
# Changes in land and sea use - Urbanisation

- Urban areas have more than doubled since 1992 (IPBES 2019)
- Replaces existing habitat
- Leads to habitat fragmentation
- Perturbs 'natural processes' e.g. as flooding and nutrient cycling
- Leads to additional direct & indirect mortality
- Separates people from nature

# Nature-based solutions for People and Nature



# Types of SuDS



# So, are they any good for amphibians?

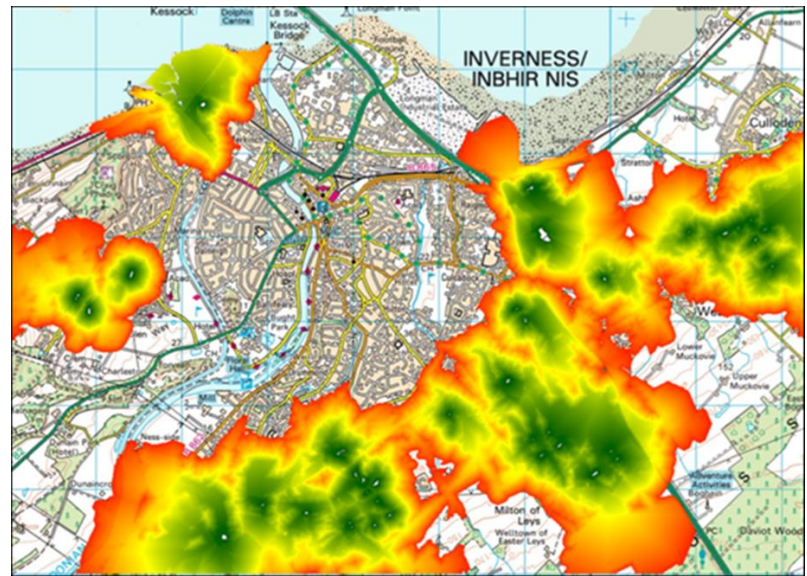
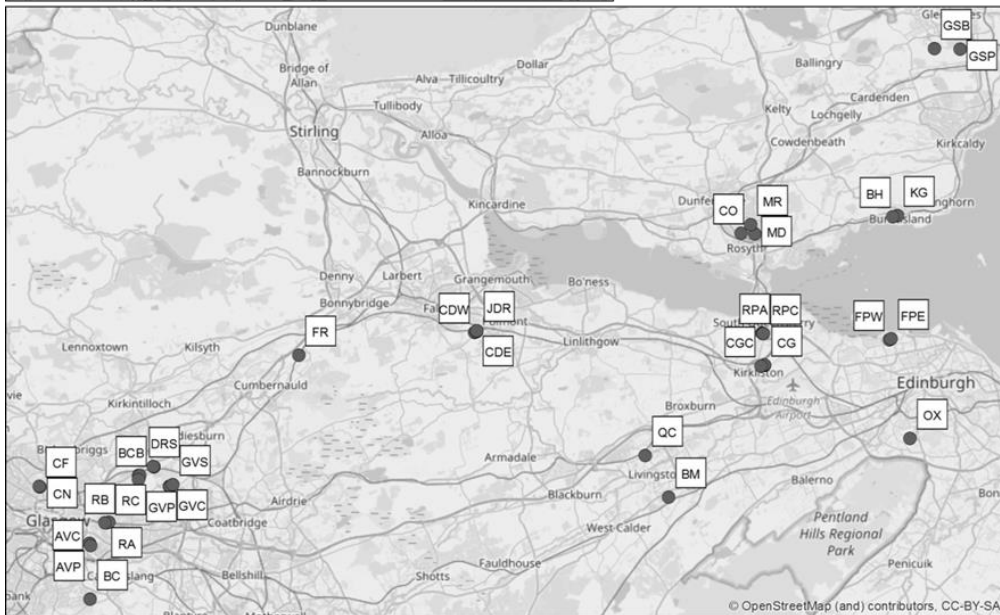
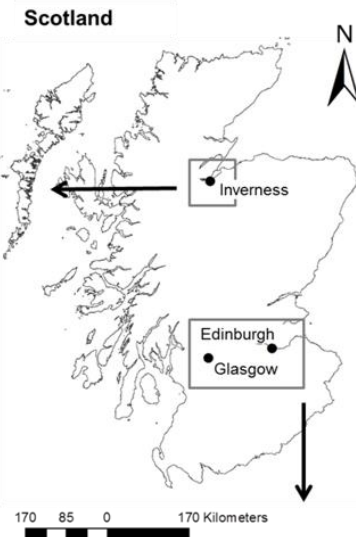
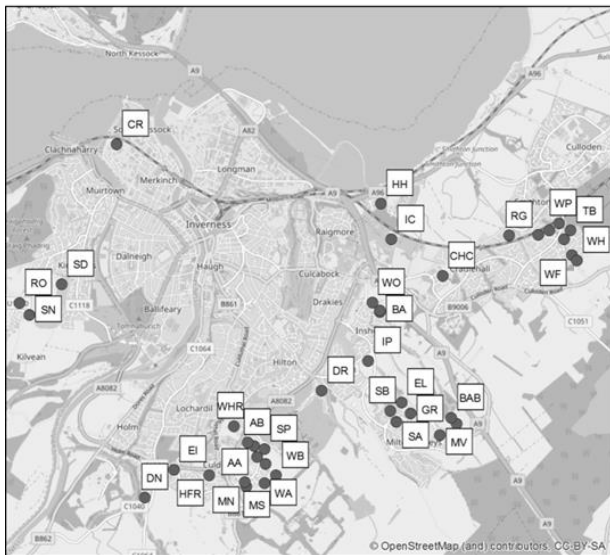
- Yes
- All Scottish native amphibians (except *Epidalea calamita*) occur in SuDS
- Some high breeding populations
- High genetic diversity (high allelic richness, comparable to countryside sites in National Parks)
- Gene flow between sites (low  $F_{ST}$  mean 0.058, max 0.187)

O'Brien (2015) *Urban Ecosyst* 18(1):321-331

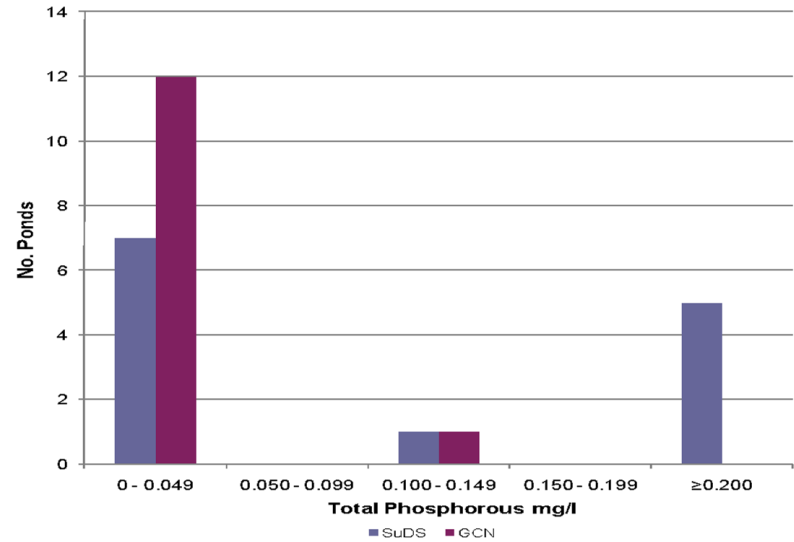
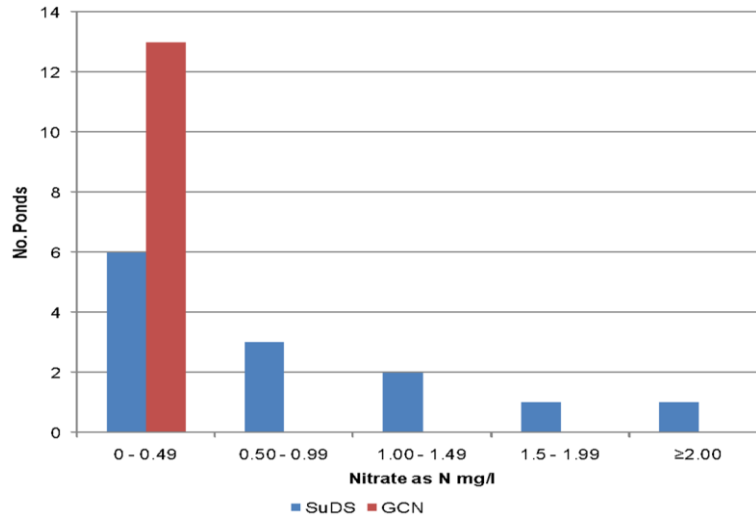
Rae et al(2019) *Ecol. Indicators* 98: 1-8

Jehle et al. (2023) *Diversity* 15(6) 738

# SuDS in clusters



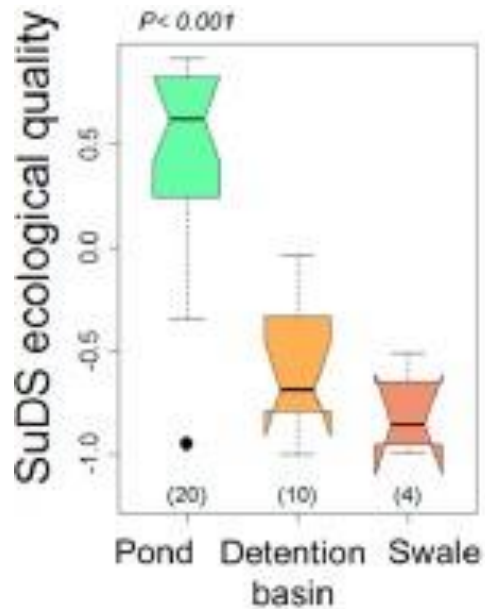
# Isn't pollution a problem?



# The Good and the Ugly



# Good design is key



Miró et al. (2018) Landscape and urban planning, 180, pp.93-102

# Benefits for all?

- Less affluent neighbourhoods have SuDS of lower ecological quality.
- Ponds offer opportunities to experience more diverse nature than other SuDS.
- SuDS ecological quality is linked to pond and surrounding habitat characteristics.
- Features influencing SuDS ecological quality are amenable to design and management.

Miró et al. (2018) *Landscape and urban planning*, 180, 93-102

# Native broadleaved trees / shrubs



# Mowing regimes – let the grass grow under your feet – cut once or twice a year



# Can SuDS be a welcoming place for people to experience nature?



# What next?

- Ongoing research into SuDS biodiversity
- Transport Scotland funded guidance
- Life history of Pyrenean newts



O'Brien, D., Hall, J. E., Miró, A., O'Brien, K., & Jehle, R. (2021). A co-development approach to conservation leads to informed habitat design and rapid establishment of amphibian communities. *Ecological Solutions and Evidence*, 2(1), e12038. <https://doi.org/10.1002/2688-8319.12038>

Miró, A., Hall, J. E., Brae, M., & O'Brien, C. D. (2018). Links between ecological and human wealth in drainage ponds in a fast-expanding city, and proposals for design and management. *Landscape and Urban Planning*, 180, 93-102. <https://doi.org/10.1016/j.landurbplan.2018.08.013>

Miró, A., O'Brien, D., Tomàs, J., Buchaca, T., Sabás, I., Osorio, V., Lucati, F., Pou-Rovira, Q., & Ventura, M. (2020). Rapid amphibian community recovery following removal of non-native fish from high mountain lakes. *Biological Conservation*, 251, 108783. <https://doi.org/10.1016/j.biocon.2020.108783>

Miró, A., & Ventura, M. (2020). Introduced fish in Pyrenean high mountain lakes: impact on amphibians and other organisms, and conservation implications. *Limnetica*, 39(1), 283-297. <https://doi.org/10.23818/limn.39.19>

Miró, A., Sabás, I., & Ventura, M. (2018). Large negative effect of non-native trout and minnows on Pyrenean lake amphibians. *Biological Conservation*, 218, 144-153. <https://doi.org/10.1016/j.biocon.2017.12.030>

Miró, A., & Ventura, M. (2015). Evidence of exotic trout mediated minnow invasion in Pyrenean high mountain lakes. *Biological Invasions*, 17(2), 791-803. <https://doi.org/10.1007/s10530-014-0769-z>

Miró, A., & Ventura, M. (2013). Historical use, fishing management and lake characteristics explain the presence of non-native trout in Pyrenean lakes: implications for conservation. *Biological Conservation*, 167, 17-24. <https://doi.org/10.1016/j.biocon.2013.07.016>