

# The impact of aquatic alien plants and crayfish control methods on ecosystem services



Gaëtan De Baene, Marie Patinet, Sonia Vanderhoeven, Arnaud Monty



The RIPARIAS project has received funding from the LIFE Programme of the European Union



Reaching Integrated and Prompt Action  
in Response to Invasive Alien Species

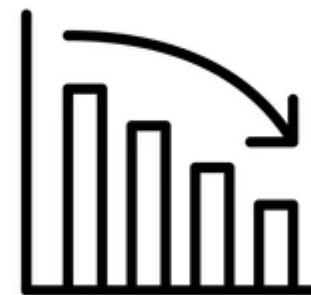
# Controlling invasive species: where and how ?

LIFE RIPARIAS aims at improving **priorization** in IAS control → where and how to manage?

Mainly targets **EU-listed species**











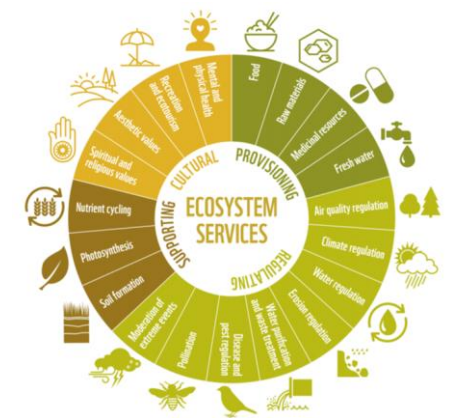
Assess the impacts of control methods on ecosystem services?







Assess the impacts of control methods on ecosystem services?

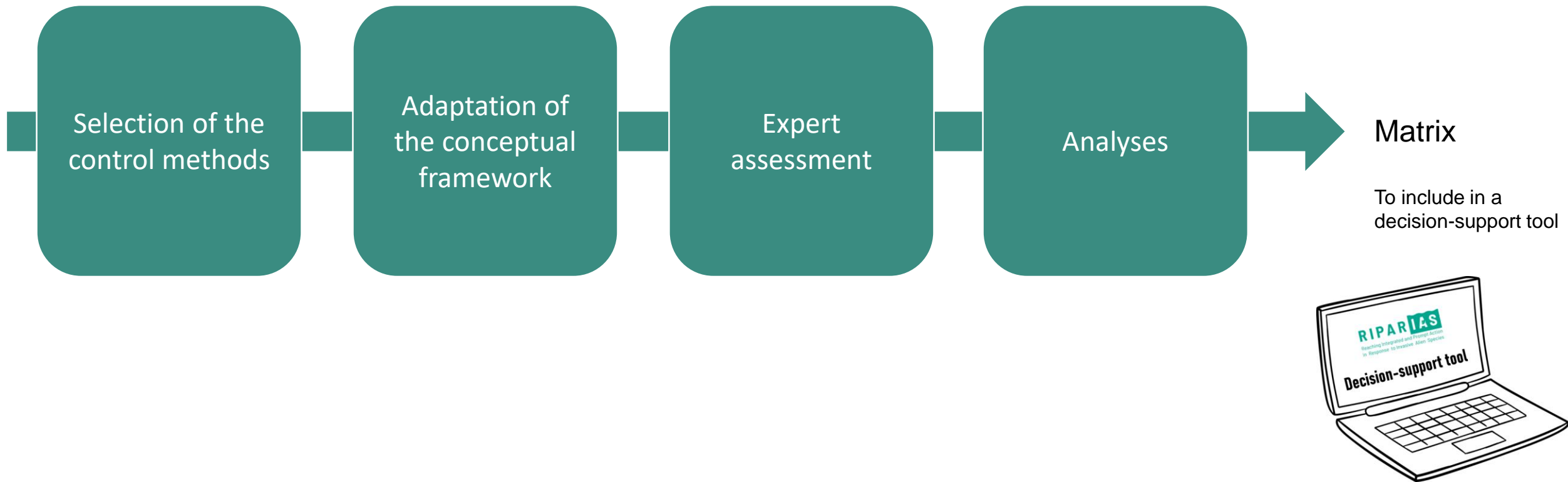




# Assessing the impact of control methods on ecosystem services - Workflow



# Assessing the impact of control methods on ecosystem services - Workflow



# Assessing the impact of control methods on ecosystem services - Workflow





# Selection of the control methods

## **Scientific literature review (SCOPUS)**

→ 358 record (species x technique) for plants and 181 for crayfish

## **“Grey literature” additional review (CABI, IUCN, LIFE, field guides, etc.)**

→ 90+ records for plants and 55 for crayfish



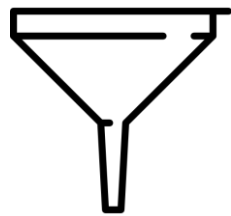
# Selection of the control methods

## Scientific literature review (SCOPUS)

→ 358 record (species x technique) for plants and 181 for crayfish

## “Grey literature” additional review (CABI, IUCN, LIFE, field guides, etc.)

→ 90+ records for plants and 55 for crayfish



Synthesis  
(eradication-control-ineffective)



## Discussion with experts









- Efficiency (eradication > control)
- Actual feasibility
- Acceptability



List of control  
methods







# Selection of the control methods

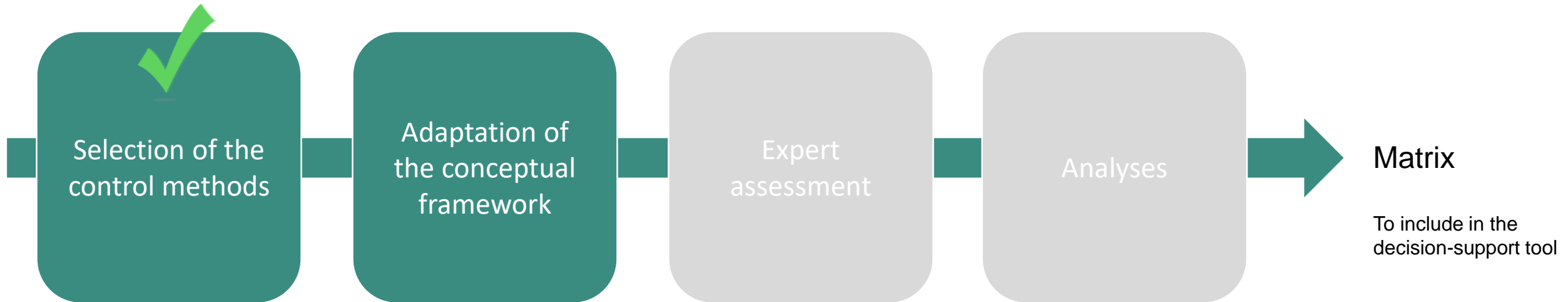
Methods	Description	Duration	What's expected?	Species example		Methods	Description	Duration	What's expected?	Species example	
Light deprivation : floating cover	Shades sheeting floating over the weed mass to prevent light reaching the target infestation, thereby limiting plant growth and preventing flower and seed production. Manual aftercare	4 month	Eradication	<i>Ludwigia</i> spp., <i>Cabomba caroliniana</i>		Mechanical removal: terrestrial machines (aquatic species)	Mechanical uprooting and collection of plants with terrestrials machines from the banks. Manual aftercare	One operation and manual aftercare (3 to 4 years)	Eradication or good level of control	<i>Hydrocotyle ranunculoides</i> , <i>Ludwigia</i> spp., <i>Myriophyllum aquaticum</i> , <i>M. heterophyllum</i>	
Light deprivation : benthic cover	Benthic blankets sit over the substrate at the bottom of a water body, both compressing aquatic plants and blocking out sunlight. Manual aftercare.	4 month	Eradication	<i>Lagarosiphon major</i> , <i>Cabomba caroliniana</i> , <i>Myriophyllum aquaticum</i> , <i>M. heterophyllum</i>		Biological control agent: grass carp	Introduction of sterile fish into a closed and controlled environment to prevent fish from escaping	2 to 3 years and then fish removed from the pond	Control	<i>Cabomba caroliniana</i> , <i>Lagarosiphon major</i> , <i>Hydrocotyle ranunculoides</i>	
Manual removal: hand pulling	Manually pulling plants out by the roots	One operation or more	Eradication with small population otherwise control	<i>Ludwigia</i> spp., <i>Lagarosiphon major</i> , <i>Cabomba caroliniana</i> , <i>Myriophyllum heterophyllum</i> , <i>M. aquaticum</i> , <i>Hydrocotyle ranunculoides</i>		Substrate removal: mechanical dredging	To dredge the bottom sediments with roots, rhizomes or any other part of the invasive plant targeted. Often preceded by a drying out.	Twice a year for 2 to 3 years. Manual aftercare	Eradication or good level of control	<i>Ludwigia</i> spp., <i>Cabomba caroliniana</i> , <i>Myriophyllum aquaticum</i>	
Mechanical removal: aquatic/floating machines	Mechanical uprooting and collection of plants with floating machines. Manual aftercare	One operation and manual aftercare (3 to 4 years)	Eradication or good level of control	<i>Ludwigia</i> spp., <i>Hydrocotyle ranunculoides</i> , <i>Myriophyllum aquaticum</i> , <i>M. heterophyllum</i>		Draining and filling a pond/ destruction of habitat	Filling carried out with a shovel or using machines	Permanent	Eradication	<i>Cabomba caroliniana</i> , <i>Lagarosiphon major</i> , <i>Hydrocotyle ranunculoides</i> , <i>Ludwigia</i> spp., <i>Myriophyllum aquaticum</i> , <i>Elodea</i> spp.	



# Selection of the control methods

Methods	Description	Duration	What's expected?	Species example	
Baited and unbaited trapping	Pyramid traps, conical traps, mesh traps... baited or unbaited. Very few catches of other organisms (newts, fish, etc.)	Variable	Control	<i>Faxonius virilis</i> , <i>Procambarus virginalis</i> , <i>Procambarus clarkii</i>	
Seine fishing/ seining	Nylon seine net to catch crayfish during the day. All caught fish are released	One operation or more	Control	<i>Faxonius virilis</i> , <i>Procambarus virginalis</i> , <i>Procambarus clarkii</i>	
Temporary drainage	Ponds are drained allowing water to pour out of water systems or by active pumping; A barrier is installed around the drained ponds to avoid crayfish emigration and facilitate hand capture after drainage. Liming of crayfish galleries	2 years or more	Eradication	<i>Faxonius virilis</i> , <i>Procambarus virginalis</i> , <i>Procambarus clarkii</i>	
Biological control agent: indigenous predatory fish	Introduction of pike, perche, eels...	Permanent	Control or eradication (with trapping)	<i>Faxonius virilis</i> , <i>Procambarus virginalis</i> , <i>Procambarus clarkii</i>	

# Assessing the impact of control methods on ecosystem services - Workflow





# Adaptation of the conceptual framework



Contents lists available at ScienceDirect

Ecological Indicators

journal homepage: [www.elsevier.com/locate/ecolind](http://www.elsevier.com/locate/ecolind)



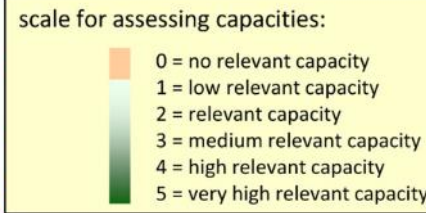
## Mapping ecosystem service supply, demand and budgets

Benjamin Burkhard<sup>a,\*</sup>, Franziska Kroll<sup>a</sup>, Stoyan Nedkov<sup>b</sup>, Felix Müller<sup>a</sup>

<sup>a</sup> Institute for the Conservation of Natural Resources, Department of Ecosystem Management, Ecology Centre, Christian Albrechts University Kiel, Olshausenstr. 40, 24098 Kiel, Germany

<sup>b</sup> Institute of Geophysics, Geodesy and Geography, Bulgarian Academy of Sciences, Acad. G. Bonchev Street, bl. 3, 1113 Sofia, Bulgaria

		Ecological Integrity								Σ	Regulating services										Σ	Provisioning services										Σ	Cultural services										Σ
		Abiotic heterogeneity	Biodiversity	Biotic waterflows	Metabolic efficiency	Energy Capture (Radiation)	Reduction of Nutrient loss	Storage capacity (SOM)		Local climate regulation	Global climate regulation	Flood protection	Groundwater recharge	Air Quality Regulation	Erosion Regulation	Nutrient regulation	Water purification	Pollination		Crops	Livestock	Fodder	Capture Fisheries	Aquaculture	Wild Foods	Timber	Wood Fuel	Energy	Bioremediation and Medicine	Freshwater		Recreational & Aesthetic Values	Intrinsic Value of Biodiversity										
CORINE land cover type:																																											
Continuous urban fabric	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0									
Discontinuous urban fabric	1	1	1	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0									
Industrial or commercial units	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0									
Road and rail networks	2	2	2	2	2	2	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0									
Port areas	1	1	1	0	0	0	0	0	3	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0									
Airports	1	1	1	1	1	1	1	2	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0									
Mineral extraction sites	4	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0									
Dump sites	5	3	1	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0									
Construction sites	3	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0									
Green urban areas	18	3	3	2	1	4	3	2	11	2	1	0	1	2	1	1	1	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0								
Sport and leisure facilities	16	2	2	2	1	4	3	2	9	1	1	0	2	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0								
Non-irrigated arable land	22	3	2	3	4	5	1	4	5	2	1	1	1	0	0	0	0	0	0	21	5	5	5	0	0	0	0	0	0	0	0	0	0	0	0								
Permanently irrigated land	21	3	2	5	2	5	1	3	4	3	1	0	0	0	0	0	0	0	0	18	5	5	2	0	0	0	0	0	0	0	0	0	0	0	0								
Ricefields	20	3	2	5	1	5	1	3	4	2	0	0	0	0	0	0	0	0	0	7	5	0	2	0	0	0	0	0	0	0	0	0	0	0	0								
Vineyards	14	3	2	3	1	3	0	2	3	1	1	0	0	0	0	0	0	0	0	5	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0								
Fruit trees and berries	21	4	3	4	2	3	2	3	19	2	2	2	2	2	2	1	1	5	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0								
Olive groves	17	3	2	3	2	3	1	3	7	1	1	0	1	1	1	1	1	1	0	12	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0								
Pastures	24	2	2	4	5	5	2	4	8	1	1	1	0	0	0	0	0	0	0	10	0	5	5	0	0	0	0	0	0	0	0	0	0	0	0								
Annual and permanent crops	18	2	2	3	2	4	2	3	7	2	1	1	1	1	1	1	0	0	0	20	5	5	5	0	0	0	0	0	0	0	0	0	0	0	0								
Complex cultivation patterns	20	4	3	3	2	4	1	3	5	2	1	1	0	0	0	0	0	0	0	9	4	0	3	0	0	0	0	0	0	0	0	0	0	0	0								
Agriculture & natural vegetation	19	3	3	3	2	3	2	3	13	3	2	1	2	1	3	0	1	0	0	21	3	3	2	0	0	0	0	0	0	0	0	0	0	0	0	0							
Agro-forestry areas	27	4	4	4	3	4	4	4	13	2	1	1	1	1	1	1	1	1	1	14	3	3	2	0	0	0	0	0	0	0	0	0	0	0	0	0							
Broad-leaved forest	31	3	4	5	4	5	5	5	39	5	4	3	2	5	5	5	5	5	5	21	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0							
Coniferous forest	30	3	4	4	4	5	5	5	39	5	4	3	2	5	5	5	5	5	5	21	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0							
Mixed forest	32	3	5	4	4	5	5	5	39	5	4	3	2	5	5	5	5	5	5	21	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0							
Natural grassland	30	3	5	4	4	4	5	5	22	2	3	1	1	0	0	0	0	0	0	5	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0								
Moors and heathland	30	3	4	4	5	4	5	5	20	4	3	2	2	0	0	0	0	0	0	3	4	2	10	0	0	0	0	0	0	0	0	0	0	0	0	0							
Sclerophyllous vegetation	21	3	4	2	3	3	4	2	7	2	1	1	1	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0								
Transitional woodland shrub	21	3	4	2	3	3	4	2	3	1	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0								
Beaches, dunes and sand plains	10	3	3	1	1	1	0	1	6	0	0	5	1	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0								
Bare rock	6	3	3	0	0	0	0	0	3	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0								
Sparsely vegetated areas	9	2	3	1	0	1	1	1	3	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0								
Burnt areas	6	2	1	0	0	0	0	3	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0								
Glaciers and perpetual snow	3	2	1	0	0	0	0	0	10	3	3	0	4	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0								
Inland marshes	25	3	2	4	4	4	3	5	14	2	2	4	2	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0								
Peatbogs	29	3	4	4	4	4	5	5	24	4	5	3	3	0	0	0	0	0	0	3	4	2	5	0	0	0	0	0	0	0	0	0	0	0	0	0							
Salt marshes	23	2	3	4	3	3	3	5	8	1	0	5	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0								
Salines	2	1	1	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0								
Intertidal flats	13	2	3	0	2	1	4	1	7	1	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0								
Water courses	18	4	4	0	3	3	3	1	10	1	0	2	1	0	0	0	0	0	0	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0								
Water bodies	23	4	4	0	4	4	3	4	7	2	1	1	2	0	0	0	0	0	0	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0								
Coastal lagoons	25	4	4	0	5	5	3	4	5	1	0	4	0	0	0	0	0	0	0	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0								
Estuaries	21	3	3	0	5	5	3	2	9	0	0	3	0	0	0	0	0	0	0	3	0	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0							
Sea and ocean	15	2	2	0	3	3	4	1	13	3	5	0	0	0	0	0	0	0	0	11	0	1	5	5	4	0	0	0	0	0	0	0	0	0	0	0							



	Service 1	Service 2	Service 3	Service 4	Service 5
Ecosystem 1	1	2	1	0	5
Ecosystem 2	5	2	2	1	0
Ecosystem 3	2	2	1	3	0
Ecosystem 4	1	1	4	0	0
Ecosystem 5	1	1	2	2	0

# Adaptation of the conceptual framework

Control methods?

Are all the services relevant?

Different species?

	Service 1	Service 2	Service 3	Service 4	Service 5
Ecosystem 1	1	2	1	0	5
Ecosystem 2	5	2	2	1	0
Ecosystem 3	2	2	1	3	0
Ecosystem 4	1	1	4	0	0
Ecosystem 5	1	1	2	2	0

Different ecosystems?

How to consider the temporal aspect?





# Adaptation of the conceptual framework





# Adaptation of the conceptual framework





# Adaptation of the conceptual framework



# Adaptation of the conceptual framework

Control methods?

Are all the services relevant?

Different species?

	Service 1	Service 2	Service 3	Service 4	Service 5
Ecosystem 1	1	2	1	0	5
Ecosystem 2	5	2	2	1	0
Ecosystem 3	2	2	1	3	0
Ecosystem 4	1	1	4	0	0
Ecosystem 5	1	1	2	2	0

Different ecosystems?

How to consider the temporal aspect?





# Adaptation of the conceptual framework

Control methods?

Are all the services relevant?

Different species?

	Service 1	Service 2	Service 3	Service 4	Service 5
Ecosystem 1	1	2	1	0	5
Ecosystem 2	5	2	2	1	0
Ecosystem 3	2	2	1	3	0
Ecosystem 4	1	1	4	0	0
Ecosystem 5	1	1	2	2	0

Different ecosystems?

How to consider the temporal aspect?

*That's much too many cells !!!*



# Adaptation of the conceptual framework

## Assumptions

- A similar control method can be used (and evaluated) for several species
- Control actions are undertaken in typical situations (*i.e.* in typically invaded ecosystems)
- Not all the ecosystem services of the CICES are relevant





# Adaptation of the conceptual framework

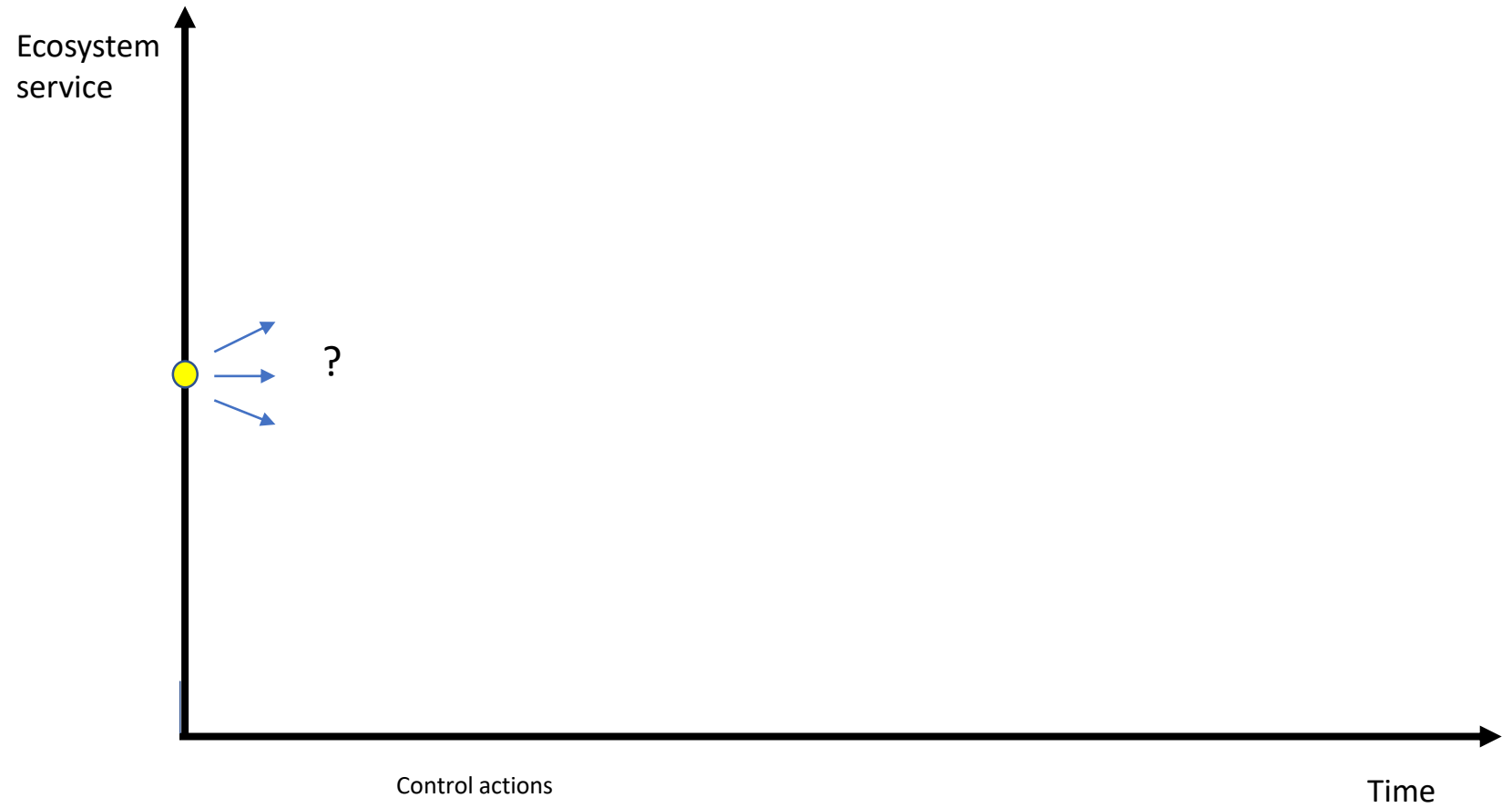
	Ecosystem service 1		Ecosystem service 2		Ecosystem service 3		Ecosystem service 4		...
	Over 1 year	Over 5 years	Over 1 year	Over 5 years	Over 1 year	Over 5 years	Over 1 year	Over 5 years	
Control method 1									
Control method 2									
Control method 3									
Control method 4									
...									

# Adaptation of the conceptual framework

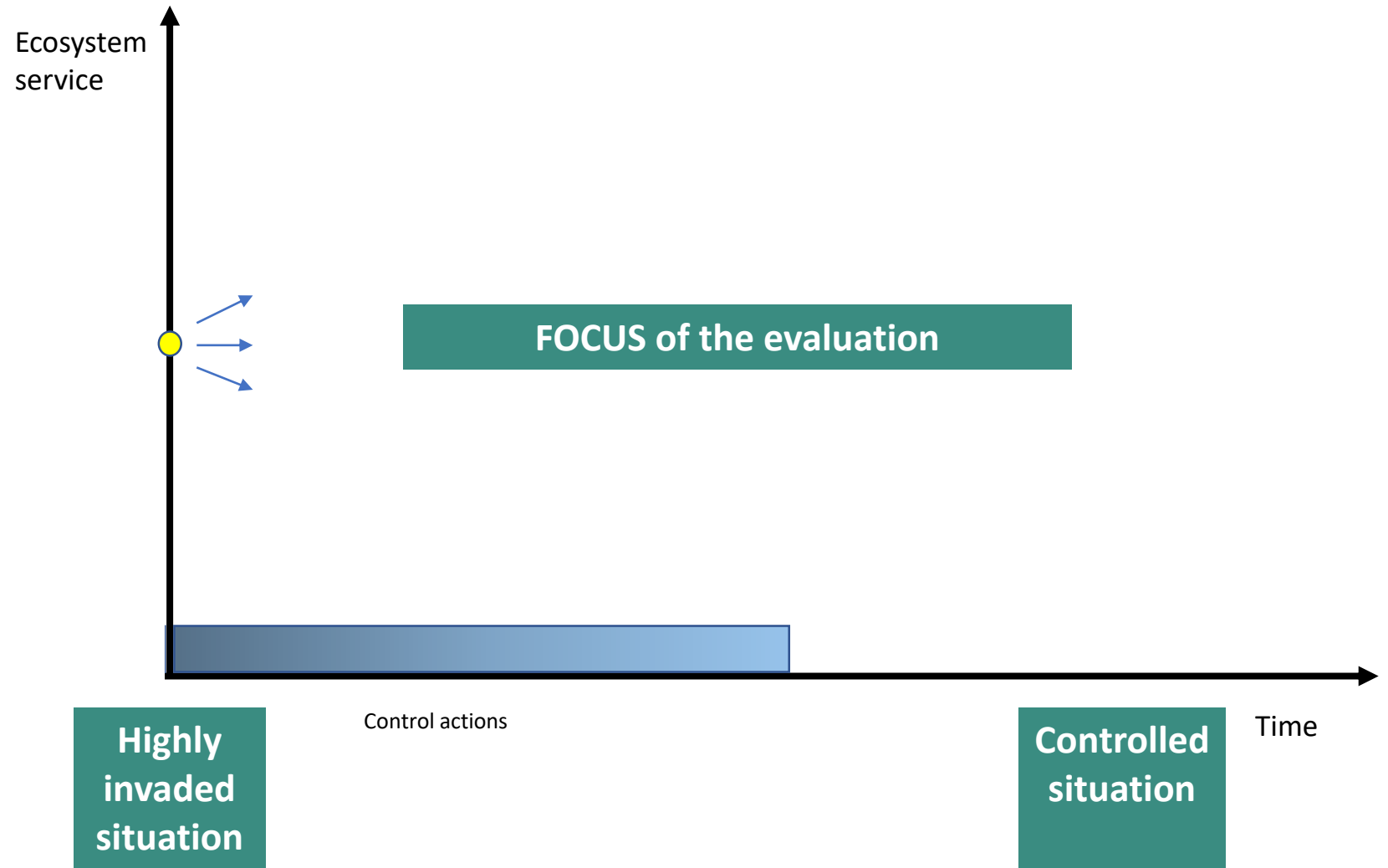
	Ecosystem service 1		Ecosystem service 2		Ecosystem service 3		Ecosystem service 4		...
	Over 1 year	Over 5 years	Over 1 year	Over 5 years	Over 1 year	Over 5 years	Over 1 year	Over 5 years	
Control method 1	<div>?</div>								
Control method 2									
Control method 3									
Control method 4									
...									



# Adaptation of the conceptual framework

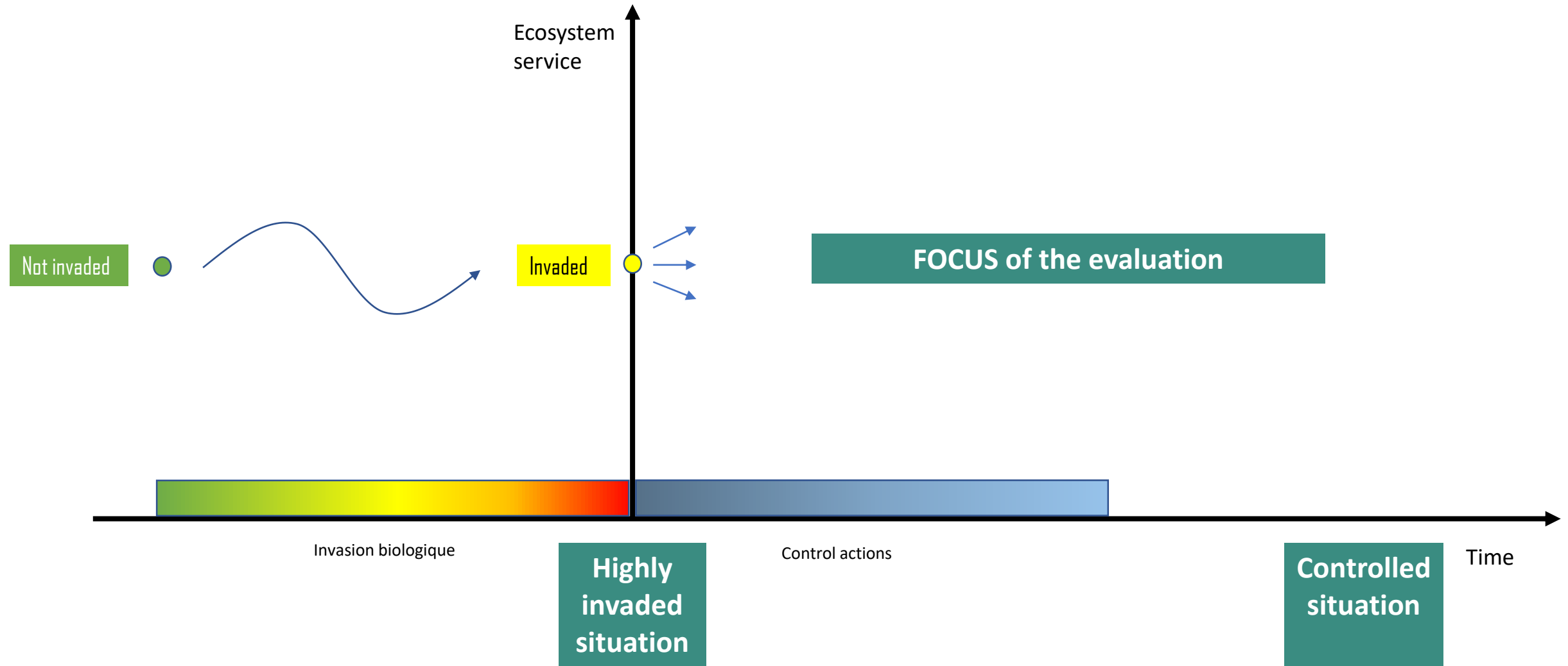


# Adaptation of the conceptual framework

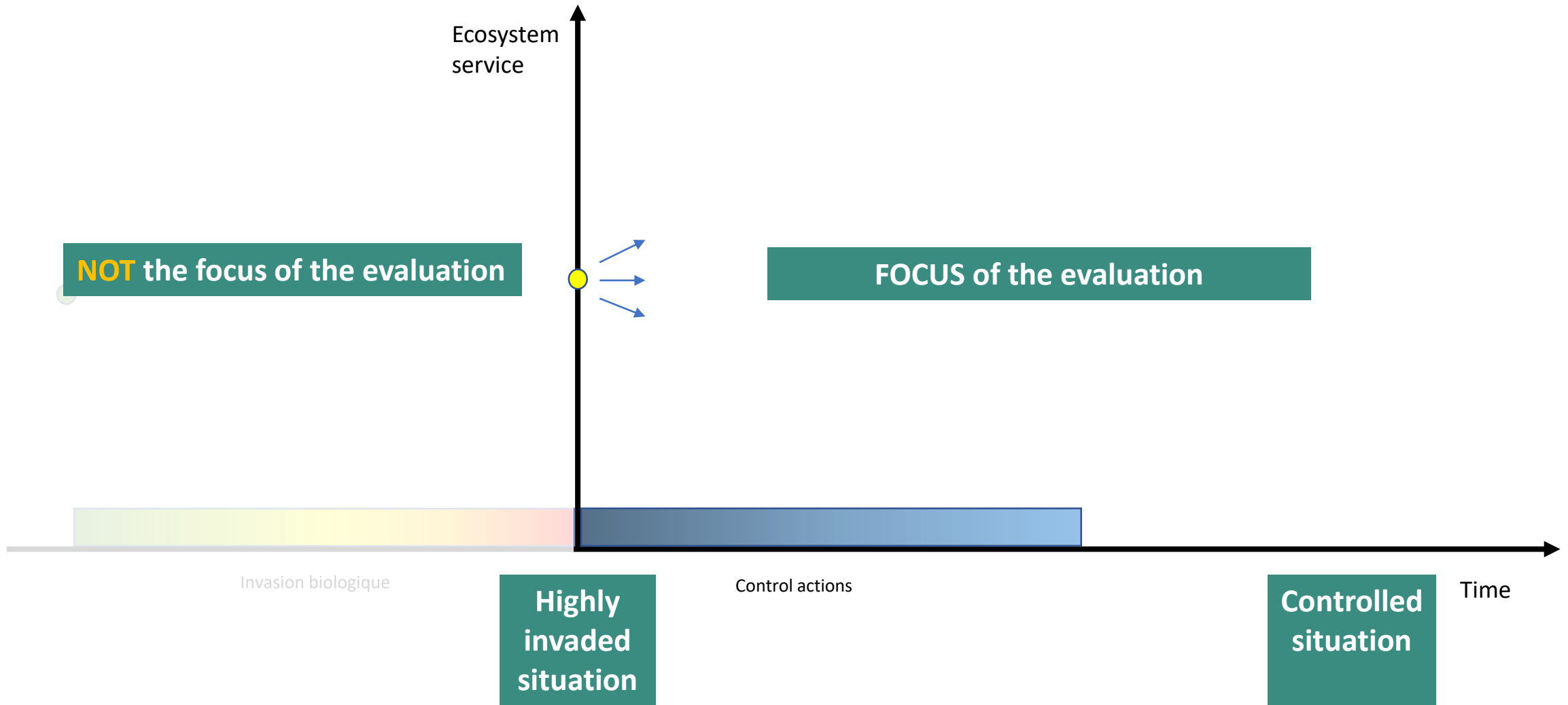




# Adaptation of the conceptual framework

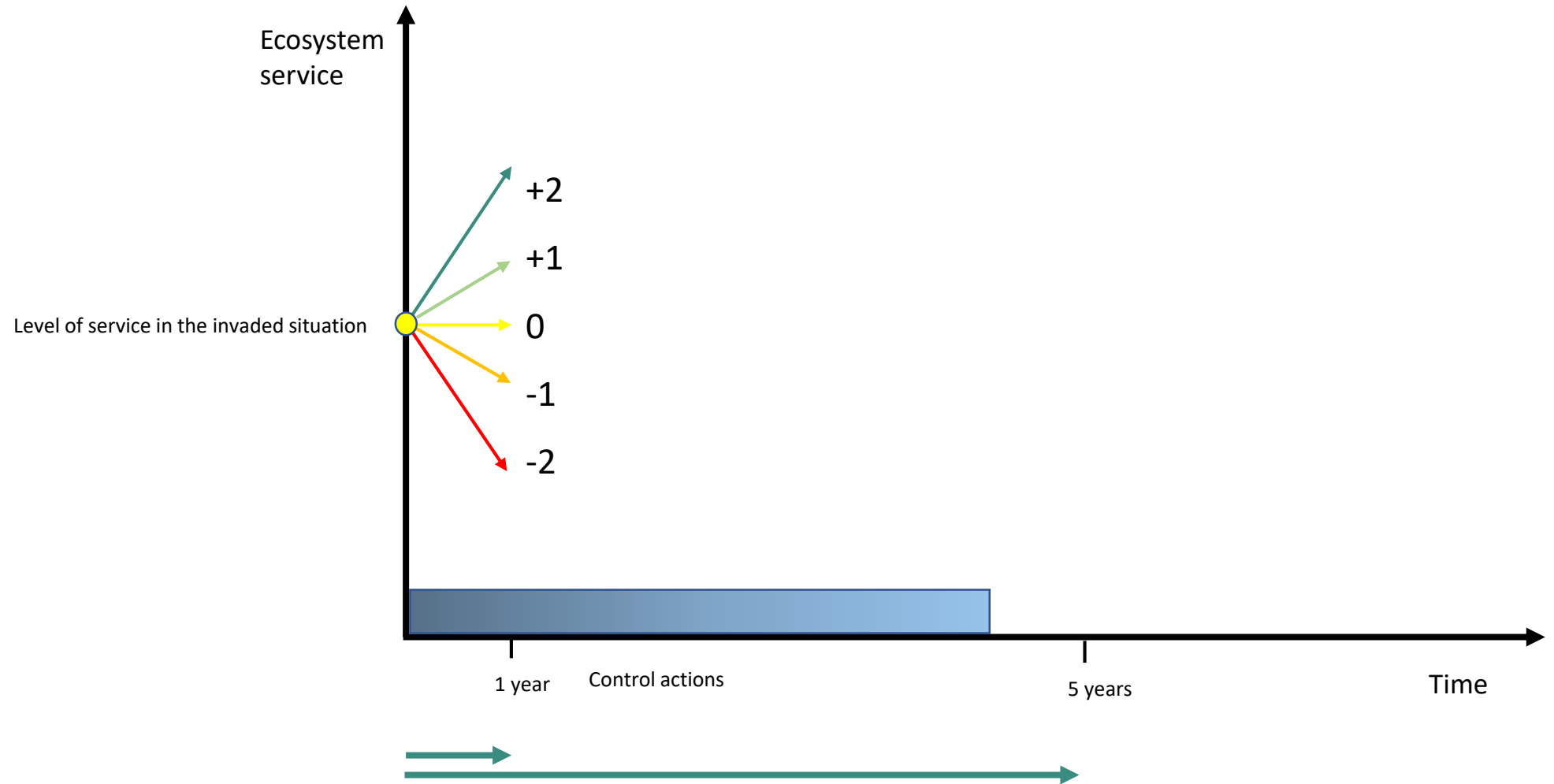


# Adaptation of the conceptual framework

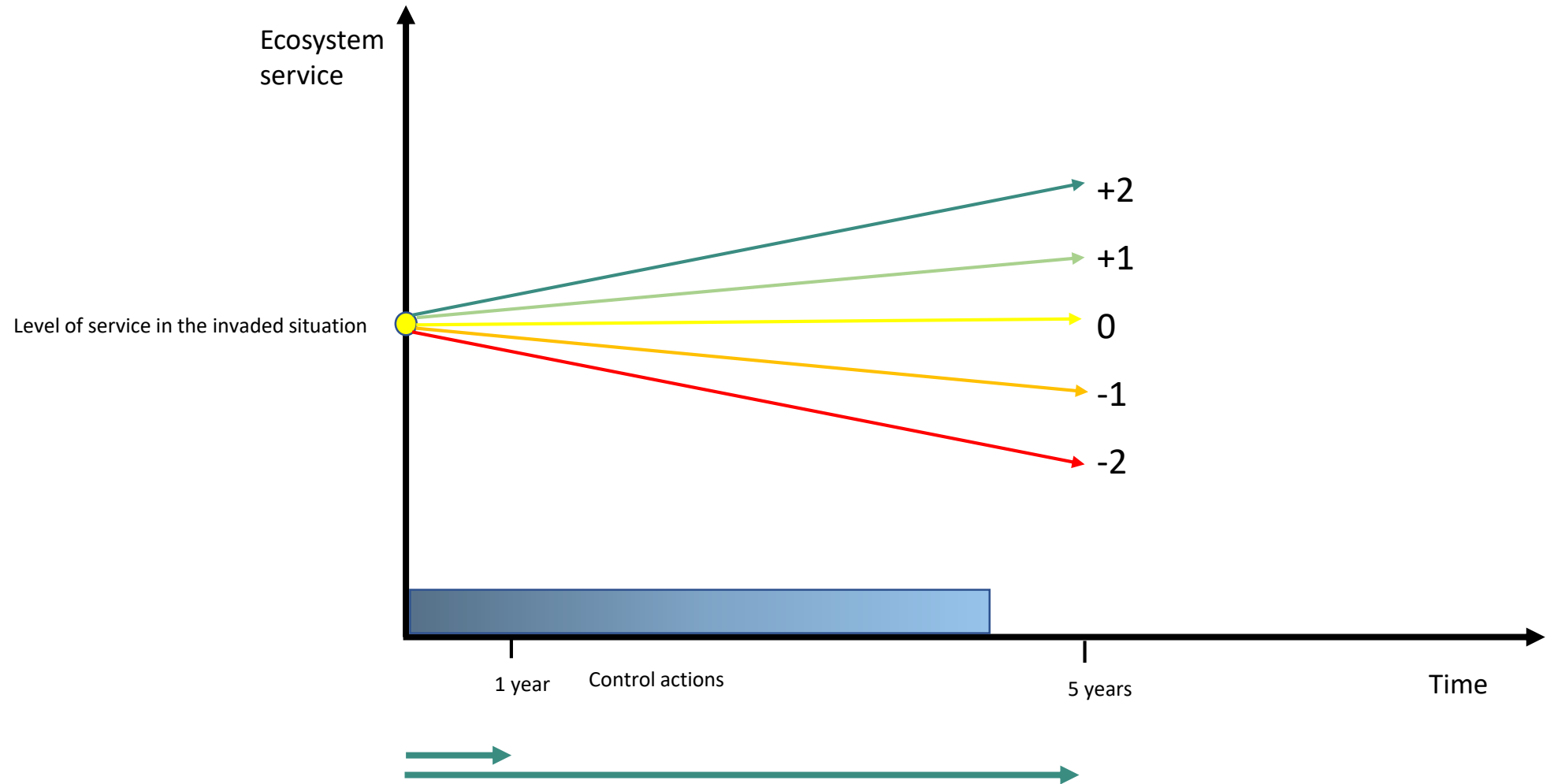




# Adaptation of the conceptual framework

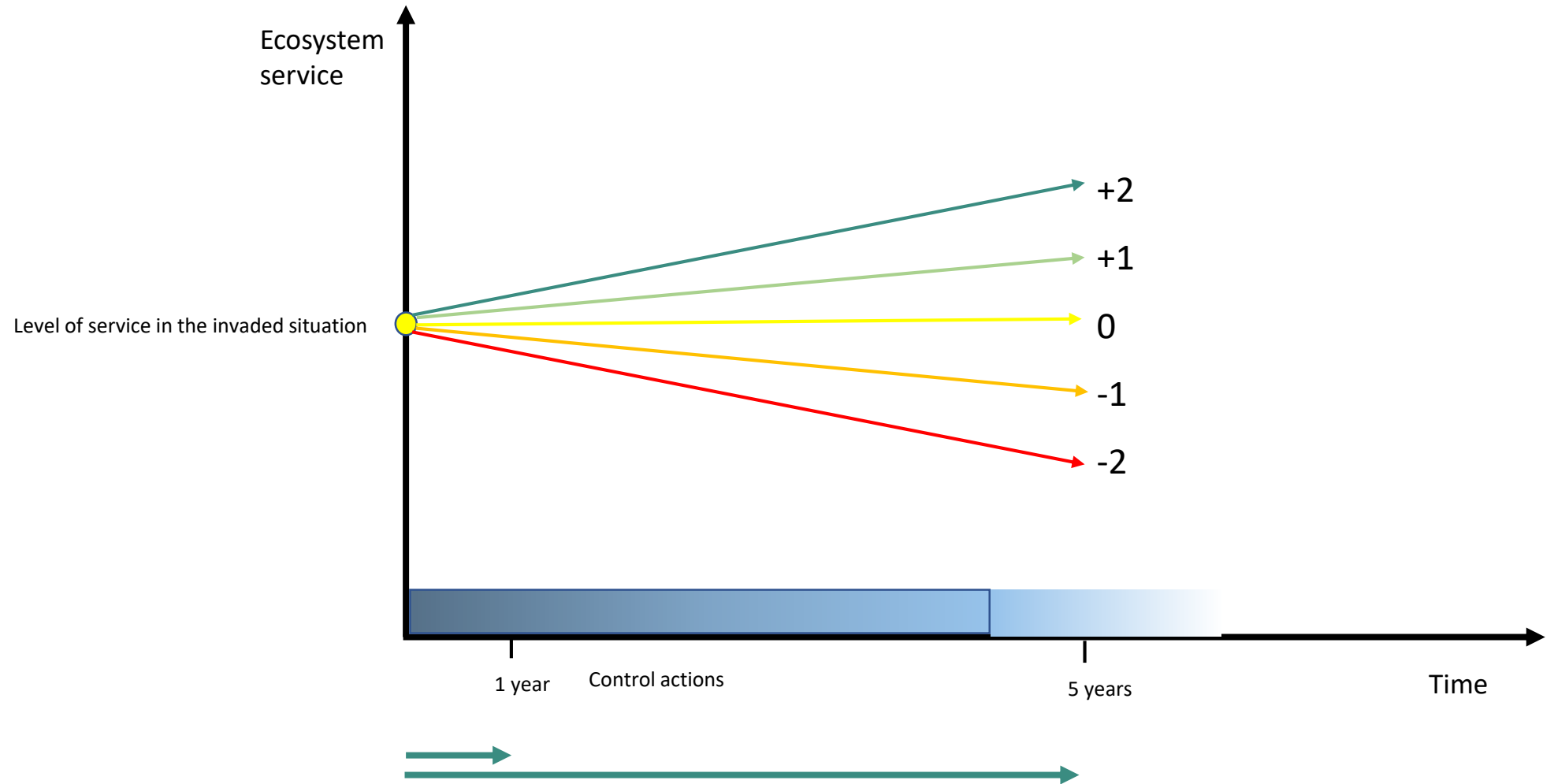


# Adaptation of the conceptual framework





# Adaptation of the conceptual framework



# Assessing the impact of control methods on ecosystem services - Workflow





# Expert assessment

- SurveyMonkey® online survey
  - Large email diffusion (March to July 2022)
  - 2 workshops (Uliège, ICAIS)
  - Technical explanations of the control methods
- 26 different experts participated
  - Crayfish: 12.2 evaluations per cell
  - Aquatic plants: 8.4 evaluations per cell

## 15. What are the impacts of those methods on the "Mediation of mass flows" Ecosystem Service? E.g. Erosion / landslide / gravity flow protection; vegetation cover protecting/stabilising terrestrial, coastal and

marine ecosystems, coastal wetlands, dunes; vegetation on slopes also preventing avalanches. Transport and storage of sediment by rivers, lakes

	Mediation of mass flows (1 year)	Mediation of mass flows (5 years)
Light deprivation: floating cover	<input type="text"/>	<input type="text"/>
Light deprivation: benthic cover	+2	<input type="text"/>
Manual removal: hand pulling	+1	<input type="text"/>
Mechanical removal: floating machines	0	<input type="text"/>
Mechanical removal: terrestrial machines	-1	<input type="text"/>
	-2	<input type="text"/>
	irrelevant	<input type="text"/>
Introduction of sterile grass carp	<input type="text"/>	<input type="text"/>
Substrate removal: mechanical dredging	<input type="text"/>	<input type="text"/>
Refilling the pond and replacing by terrestrial vegetation	<input type="text"/>	<input type="text"/>
No method applied	<input type="text"/>	<input type="text"/>

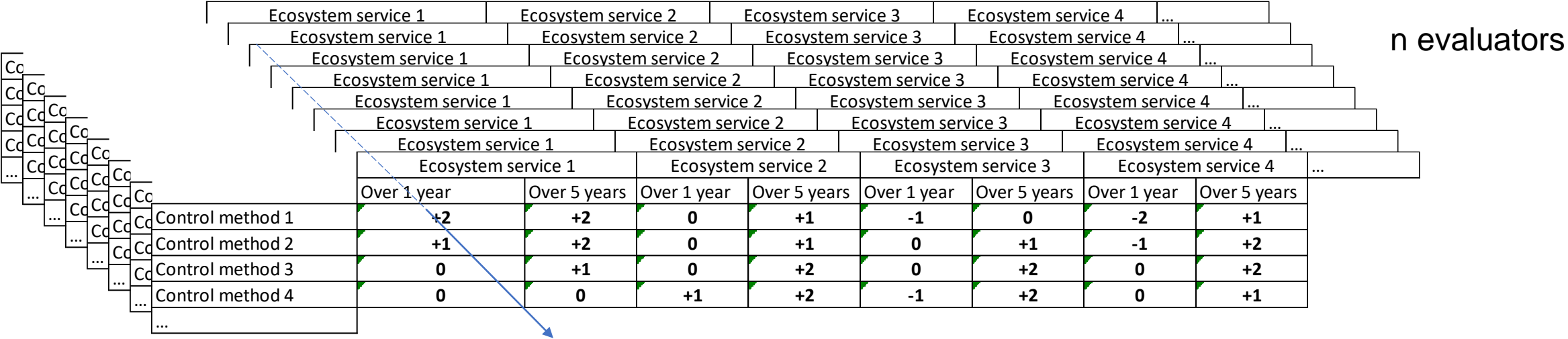
Comment (not mandatory)



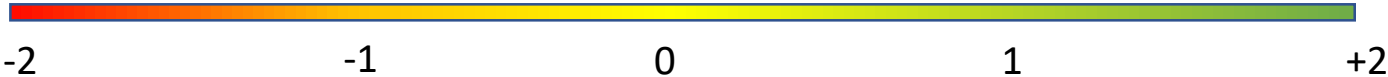
# Assessing the impact of control methods on ecosystem services - Workflow



# Analyses



Average      *How did the ecosystem service evolve?*



ICC (2,k)      *Is the evaluation reliable?*  
« good » > 0.75 (Koo & Li 2016)



# Assessing the impact of control methods on ecosystem services - Workflow



# Matrices



	Provisioning						Regulation and maintenance										Cultural			
Average 1 year	Nutrition : biomass	Nutrition : water	Materials : biomass	Materials : water	Biomass-based energy sources	Mechanical energy	Mediation by biota	Mediation by ecosystems	Mediation of mass flows	Mediation of liquid flows	Mediation of gaseous / air flows	Lifecycle maintenance, habitat and gene pool protection	Pest and disease control	Soil formation and composition	Water conditions	Atmospheric composition and climate regulation	Physical and experiential interactions with biota, ecosystems, and landscapes	Intellectual and representational interactions with biota, ecosystems, and landscapes	Spiritual and/or emblematic interactions with biota, ecosystems, and landscapes	Other cultural outputs
Light deprivation: floating cover	-1.4	-0.5	-1.0	-0.1	-0.5		-1.6	-1.3	-1.0	-0.7		-1.2	0.3	-1.0	-1.6	-1.0	-0.7	-0.6	-0.4	
Light deprivation: benthic cover	-1.0	-0.4	-0.9	0.0	-0.3		-1.3	-0.9	-0.9	-0.6		-1.0	0.0	-1.2	-1.5	-1.0	-0.3	-0.4	-0.4	
Manual removal: hand pulling (aquatic)	0.1	-0.1	-0.5	0.2	0.3		-0.3	-0.2	-0.3	0.1		0.0	0.0	-0.2	0.1	-0.2	0.3	0.4	0.3	
Mechanical removal: aquatic/floating	-0.9	-0.2	-0.9	0.1	0.5		-0.8	-0.6	-0.8	-0.2		-1.1	0.0	-0.5	-0.6	-0.2	-0.1	-0.1	-0.1	
Mechanical removal: terrestrial machines	-0.7	-0.3	-1.0	0.1	0.5		-0.5	-0.5	-1.1	-0.2		-1.1	0.1	-1.0	-0.5	-0.3	-0.2	-0.2	-0.1	
Biological control agent: grass carp	-0.6	-0.3	-0.4	0.0	-0.4		-0.9	-0.5	-0.6	0.2		-1.2	0.2	-0.2	-0.6	-0.8	-0.5	-0.2	-0.3	
Substrate removal: mechanical dredging	-1.3	-1.0	-1.0	-0.2	-0.2		-1.4	-1.3	-1.3	0.1		-1.6	0.0	-1.3	-0.8	-0.2	-1.0	-0.7	-0.7	
Draining and filling a pond/ destruction of	-1.6	-1.8	-1.0	-1.8	-1.1		-2.0	-2.0	-1.9	-1.8		-1.8	0.5	-1.0	-1.7	-0.8	-1.8	-1.5	-1.6	

Overall reliability (95% interval):  $0,89 < ICC(2,k) < 0,93$

# Matrices



	Provisioning						Regulation and maintenance										Cultural			
Average 1 year	Nutrition : biomass	Nutrition : water	Materials : biomass	Materials : water	Biomass-based energy sources	Mechanical energy	Mediation by biota	Mediation by ecosystems	Mediation of mass flows	Mediation of liquid flows	Mediation of gaseous / air flows	Lifecycle maintenance, habitat and gene pool protection	Pest and disease control	Soil formation and composition	Water conditions	Atmospheric composition and climate regulation	Physical and experiential interactions with biota, ecosystems, and landscapes	Intellectual and representational interactions with biota, ecosystems, and landscapes	Spiritual and/or emblematic interactions with biota, ecosystems, and landscapes	Other cultural outputs
Light deprivation: floating cover	-1.4	-0.5	-1.0	-0.1	-0.5		-1.6	-1.3	-1.0	-0.7		-1.2	0.3	-1.0	-1.6	-1.0	-0.7	-0.6	-0.4	
Light deprivation: benthic cover	-1.0	-0.4	-0.9	0.0	-0.3		-1.3	-0.9	-0.9	-0.6		-1.0	0.0	-1.2	-1.5	-1.0	-0.3	-0.4	-0.4	
Manual removal: hand pulling (aquatic)	0.1	-0.1	-0.5	0.2	0.3		-0.3	-0.2	-0.3	0.1		0.0	0.0	-0.2	0.1	-0.2	0.3	0.4	0.3	
Mechanical removal: aquatic/floating	-0.9	-0.2	-0.9	0.1	0.5		-0.8	-0.6	-0.8	-0.2		-1.1	0.0	-0.5	-0.6	-0.2	-0.1	-0.1	-0.1	
Mechanical removal: terrestrial machines	-0.7	-0.3	-1.0	0.1	0.5		-0.5	-0.5	-1.1	-0.2		-1.1	0.1	-1.0	-0.5	-0.3	-0.2	-0.2	-0.1	
Biological control agent: grass carp	-0.6	-0.3	-0.4	0.0	-0.4		-0.9	-0.5	-0.6	0.2		-1.2	0.2	-0.2	-0.6	-0.8	-0.5	-0.2	-0.3	
Substrate removal: mechanical dredging	-1.3	-1.0	-1.0	-0.2	-0.2		-1.4	-1.3	-1.3	0.1		-1.6	0.0	-1.3	-0.8	-0.2	-1.0	-0.7	-0.7	
Drainage and filling a pond/ destruction of	-1.6	-1.8	-1.0	-1.8	-1.1		-2.0	-2.0	-1.9	-1.8		-1.8	0.5	-1.0	-1.7	-0.8	-1.8	-1.5	-1.6	

Overall reliability (95% interval):  $0,89 < ICC(2,k) < 0,93$



# Matrices



	Provisioning						Regulation and maintenance										Cultural			
Average 1 year	Nutrition : biomass	Nutrition : water	Materials : biomass	Materials : water	Biomass-based energy sources	Mechanical energy	Mediation by biota	Mediation by ecosystems	Mediation of mass flows	Mediation of liquid flows	Mediation of gaseous / air flows	Lifecycle maintenance, habitat and gene pool protection	Pest and disease control	Soil formation and composition	Water conditions	Atmospheric composition and climate regulation	Physical and experiential interactions with biota, ecosystems, and landscapes	Intellectual and representational interactions with biota, ecosystems, and landscapes	Spiritual and/or emblematic interactions with biota, ecosystems, and landscapes	Other cultural outputs
Light deprivation: floating cover	-1.4	-0.5	-1.0	-0.1	-0.5		-1.6	-1.3	-1.0	-0.7		-1.2	0.3	-1.0	-1.6	-1.0	-0.7	-0.6	-0.4	
Light deprivation: benthic cover	-1.0	-0.4	-0.9	0.0	-0.3		-1.3	-0.9	-0.9	-0.6		-1.0	0.0	-1.2	-1.5	-1.0	-0.3	-0.4	-0.4	
Manual removal: hand pulling (aquatic)	0.1	-0.1	-0.5	0.2	0.3		-0.3	-0.2	-0.3	0.1		0.0	0.0	-0.2	0.1	-0.2	0.3	0.4	0.3	
Mechanical removal: aquatic/floating	-0.9	-0.2	-0.9	0.1	0.5		-0.8	-0.6	-0.8	-0.2		-1.1	0.0	-0.5	-0.6	-0.2	-0.1	-0.1	-0.1	
Mechanical removal: terrestrial machines	-0.7	-0.3	-1.0	0.1	0.5		-0.5	-0.5	-1.1	-0.2		-1.1	0.1	-1.0	-0.5	-0.3	-0.2	-0.2	-0.1	
Biological control agent: grass carp	-0.6	-0.3	-0.4	0.0	-0.4		-0.9	-0.5	-0.6	0.2		-1.2	0.2	-0.2	-0.6	-0.8	-0.5	-0.2	-0.3	
Substrate removal: mechanical dredging	-1.3	-1.0	-1.0	-0.2	-0.2		-1.4	-1.3	-1.3	0.1		-1.6	0.0	-1.3	-0.8	-0.2	-1.0	-0.7	-0.7	
Draining and filling a pond/ destruction of	-1.6	-1.8	-1.0	-1.8	-1.1		-2.0	-2.0	-1.9	-1.8		-1.8	0.5	-1.0	-1.7	-0.8	-1.8	-1.5	-1.6	

Overall reliability (95% interval):  $0,89 < ICC(2,k) < 0,93$

# Matrices



Average 5 years	Provisioning						Regulation and maintenance										Cultural			
	Nutrition : biomass	Nutrition : water	Materials : biomass	Materials : water	Biomass-based energy sources	Mechanical energy	Mediation by biota	Mediation by ecosystems	Mediation of mass flows	Mediation of liquid flows	Mediation of gaseous / air flows	Lifecycle maintenance, habitat and gene pool protection	Pest and disease control	Soil formation and composition	Water conditions	Atmospheric composition and climate regulation	Physical and experiential interactions with biota, ecosystems, and landscapes	Intellectual and representational interactions with biota, ecosystems, and landscapes	Spiritual and/or emblematic interactions with biota, ecosystems, and landscapes	Other cultural outputs
Light deprivation: floating cover	0.8	0.3	0.3	0.3	0.0		0.1	-0.1	0.1	0.6		1.2	0.3	-0.3	0.3	0.3	1.4	1.3	1.0	
Light deprivation: benthic cover	0.8	0.3	0.3	0.3	-0.2		0.1	0.0	0.0	0.4		1.2	0.3	-0.3	0.3	0.3	1.4	1.3	1.0	
Manual removal: hand pulling (aquatic)	1.1	0.2	0.4	0.6	0.3		0.5	0.3	0.2	0.6		1.2	0.3	0.2	0.5	0.2	1.5	1.4	1.1	
Mechanical removal: aquatic/floating	0.9	0.2	0.4	0.6	0.5		0.4	0.3	0.2	0.6		1.2	0.3	0.2	0.5	0.2	1.5	1.3	1.0	
Mechanical removal: terrestrial machines	1.0	0.2	0.4	0.6	0.5		0.5	0.4	0.2	0.6		1.1	0.3	0.0	0.5	0.2	1.5	1.3	0.8	
Biological control agent: grass carp	-0.2	0.1	0.3	0.0	-0.4		-0.6	-0.5	-0.6	0.5		0.1	-0.2	-0.3	-0.5	-0.5	0.1	0.2	-0.2	
Substrate removal: mechanical dredging	0.5	0.4	0.3	0.4	0.0		0.0	0.0	-0.1	0.4		1.1	0.5	-0.2	0.5	0.2	1.1	1.4	0.8	
Draining and filling a pond/ destruction of	-1.0	-1.8	-0.4	-1.5	-0.8		-1.5	-1.4	-1.7	-1.9		-1.2	0.3	-0.7	-2.0	0.6	-1.3	-0.9	-1.1	

Overall reliability (95% interval):  $0,89 < ICC(2,k) < 0,93$

# Matrices



	Provisioning						Regulation and maintenance										Cultural			
Average 5 years	Nutrition : biomass	Nutrition : water	Materials : biomass	Materials : water	Biomass-based energy sources	Mechanical energy	Mediation by biota	Mediation by ecosystems	Mediation of mass flows	Mediation of liquid flows	Mediation of gaseous / air flows	Lifecycle maintenance, habitat and gene pool protection	Pest and disease control	Soil formation and composition	Water conditions	Atmospheric composition and climate regulation	Physical and experiential interactions with biota, ecosystems, and landscapes	Intellectual and representational interactions with biota, ecosystems, and landscapes	Spiritual and/or emblematic interactions with biota, ecosystems, and landscapes	Other cultural outputs
Light deprivation: floating cover	0.8	0.3	0.3	0.3	0.0		0.1	-0.1	0.1	0.6		1.2	0.3	-0.3	0.3	0.3	1.4	1.3	1.0	
Light deprivation: benthic cover	0.8	0.3	0.3	0.3	-0.2		0.1	0.0	0.0	0.4		1.2	0.3	-0.3	0.3	0.3	1.4	1.3	1.0	
Manual removal: hand pulling (aquatic)	1.1	0.2	0.4	0.6	0.3		0.5	0.3	0.2	0.6		1.2	0.3	0.2	0.5	0.2	1.5	1.4	1.1	
Mechanical removal: aquatic/floating	0.9	0.2	0.4	0.6	0.5		0.4	0.3	0.2	0.6		1.2	0.3	0.2	0.5	0.2	1.5	1.3	1.0	
Mechanical removal: terrestrial machines	1.0	0.2	0.4	0.6	0.5		0.5	0.4	0.2	0.6		1.1	0.3	0.0	0.5	0.2	1.5	1.3	0.8	
Biological control agent: grass carp	-0.2	0.1	0.3	0.0	-0.4		-0.6	-0.5	-0.6	0.5		0.1	-0.2	-0.3	-0.5	-0.5	0.1	0.2	-0.2	
Substrate removal: mechanical dredging	0.5	0.4	0.3	0.4	0.0		0.0	0.0	-0.1	0.4		1.1	0.5	-0.2	0.5	0.2	1.1	1.4	0.8	
Drainage and filling a pond/ destruction of	-1.0	-1.8	-0.4	-1.5	-0.8		-1.5	-1.4	-1.7	-1.9		-1.2	0.3	-0.7	-2.0	0.6	-1.3	-0.9	-1.1	

Overall reliability (95% interval):  $0,89 < ICC(2,k) < 0,93$



# Matrices



	Provisioning						Regulation and maintenance										Cultural			
Average 5 years	Nutrition : biomass	Nutrition : water	Materials : biomass	Materials : water	Biomass-based energy sources	Mechanical energy	Mediation by biota	Mediation by ecosystems	Mediation of mass flows	Mediation of liquid flows	Mediation of gaseous / air flows	Lifecycle maintenance, habitat and gene pool protection	Pest and disease control	Soil formation and composition	Water conditions	Atmospheric composition and climate regulation	Physical and experiential interactions with biota, ecosystems, and landscapes	Intellectual and representational interactions with biota, ecosystems, and landscapes	Spiritual and/or emblematic interactions with biota, ecosystems, and landscapes	Other cultural outputs
Light deprivation: floating cover	0.8	0.3	0.3	0.3	0.0		0.1	-0.1	0.1	0.6		1.2	0.3	-0.3	0.3	0.3	1.4	1.3	1.0	
Light deprivation: benthic cover	0.8	0.3	0.3	0.3	-0.2		0.1	0.0	0.0	0.4		1.2	0.3	-0.3	0.3	0.3	1.4	1.3	1.0	
Manual removal: hand pulling (aquatic)	1.1	0.2	0.4	0.6	0.3		0.5	0.3	0.2	0.6		1.2	0.3	0.2	0.5	0.2	1.5	1.4	1.1	
Mechanical removal: aquatic/floating	0.9	0.2	0.4	0.6	0.5		0.4	0.3	0.2	0.6		1.2	0.3	0.2	0.5	0.2	1.5	1.3	1.0	
Mechanical removal: terrestrial machines	1.0	0.2	0.4	0.6	0.5		0.5	0.4	0.2	0.6		1.1	0.3	0.0	0.5	0.2	1.5	1.3	0.8	
Biological control agent: grass carp	-0.2	0.1	0.3	0.0	-0.4		-0.6	-0.5	-0.6	0.5		0.1	-0.2	-0.3	-0.5	-0.5	0.1	0.2	-0.2	
Substrate removal: mechanical dredging	0.5	0.4	0.3	0.4	0.0		0.0	0.0	-0.1	0.4		1.1	0.5	-0.2	0.5	0.2	1.1	1.4	0.8	
Draining and filling a pond/ destruction of	-1.0	-1.8	-0.4	-1.5	-0.8		-1.5	-1.4	-1.7	-1.9		-1.2	0.3	-0.7	-2.0	0.6	-1.3	-0.9	-1.1	

Overall reliability (95% interval):  $0,89 < ICC(2,k) < 0,93$

# Matrices



	Provisioning						Regulation and maintenance										Cultural			
Average 1 year	Nutrition : biomass	Nutrition : water	Materials : biomass	Materials : water	Biomass-based energy sources	Mechanical energy	Mediation by biota	Mediation by ecosystems	Mediation of mass flows	Mediation of liquid flows	Mediation of gaseous / air flows	Lifecycle maintenance, habitat and gene pool protection	Pest and disease control	Soil formation and composition	Water conditions	Atmospheric composition and climate regulation	Physical and experiential interactions with biota, ecosystems, and landscapes	Intellectual and representational interactions with biota, ecosystems, and landscapes	Spiritual and/or emblematic interactions with biota, ecosystems, and landscapes	Other cultural outputs
Baited and unbaited trapping	0.1			0.1			0.2	0.3	0.5	0.0		0.6	0.6		0.1		0.3	0.3	0.2	
Seine fishing/ seining	-0.3			0.2			0.0	0.4	0.4	0.0		0.2	0.6		0.3		-0.3	0.4	0.0	
Temporary drainage	-1.2			-1.0			-0.9	-0.9	-0.3	-0.1		-1.7	1.0		-0.1		-1.1	-0.2	-0.6	
Biological control agent: indigenous predatory fish	0.1			0.0			0.0	0.1	0.3	0.0		0.1	0.2		0.3		0.9	0.4	0.5	

Overall reliability (95% interval):  $0,79 < ICC(2,k) < 0,88$

# Matrices



	Provisioning						Regulation and maintenance										Cultural			
Average 1 year	Nutrition : biomass	Nutrition : water	Materials : biomass	Materials : water	Biomass-based energy sources	Mechanical energy	Mediation by biota	Mediation by ecosystems	Mediation of mass flows	Mediation of liquid flows	Mediation of gaseous / air flows	Lifecycle maintenance, habitat and gene pool protection	Pest and disease control	Soil formation and composition	Water conditions	Atmospheric composition and climate regulation	Physical and experiential interactions with biota, ecosystems, and landscapes	Intellectual and representational interactions with biota, ecosystems, and landscapes	Spiritual and/or emblematic interactions with biota, ecosystems, and landscapes	Other cultural outputs
Baited and unbaited trapping	0.1			0.1			0.2	0.3	0.5	0.0		0.6	0.6		0.1		0.3	0.3	0.2	
Seine fishing/ seining	-0.3			0.2			0.0	0.4	0.4	0.0		0.2	0.6		0.3		-0.3	0.4	0.0	
Temporary drainage	-1.2			-1.0			-0.9	-0.9	-0.3	-0.1		-1.7	1.0		-0.1		-1.1	-0.2	-0.6	
Biological control agent: indigenous predatory fish	0.1			0.0			0.0	0.1	0.3	0.0		0.1	0.2		0.3		0.9	0.4	0.5	

Overall reliability (95% interval):  $0,79 < ICC(2,k) < 0,88$



# Matrices



Average 1 year	Provisioning						Regulation and maintenance										Cultural			
	Nutrition : biomass	Nutrition : water	Materials : biomass	Materials : water	Biomass-based energy sources	Mechanical energy	Mediation by biota	Mediation by ecosystems	Mediation of mass flows	Mediation of liquid flows	Mediation of gaseous / air flows	Lifecycle maintenance, habitat and gene pool protection	Pest and disease control	Soil formation and composition	Water conditions	Atmospheric composition and climate regulation	Physical and experiential interactions with biota, ecosystems, and landscapes	Intellectual and representational interactions with biota, ecosystems, and landscapes	Spiritual and/or emblematic interactions with biota, ecosystems, and landscapes	Other cultural outputs
Baited and unbaited trapping	0.1			0.1			0.2	0.3	0.5	0.0		0.6	0.6		0.1		0.3	0.3	0.2	
Seine fishing/ seining	-0.3			0.2			0.0	0.4	0.4	0.0		0.2	0.6		0.3		-0.3	0.4	0.0	
Temporary drainage	-1.2			-1.0			-0.9	-0.9	-0.3	-0.1		-1.7	1.0		-0.1		-1.1	-0.2	-0.6	
Biological control agent: indigenous predatory fish	0.1			0.0			0.0	0.1	0.3	0.0		0.1	0.2		0.3		0.9	0.4	0.5	

Overall reliability (95% interval):  $0,79 < ICC(2,k) < 0,88$

# Matrices



Average 5 years	Provisioning						Regulation and maintenance										Cultural			
	Nutrition : biomass	Nutrition : water	Materials : biomass	Materials : water	Biomass-based energy sources	Mechanical energy	Mediation by biota	Mediation by ecosystems	Mediation of mass flows	Mediation of liquid flows	Mediation of gaseous / air flows	Lifecycle maintenance, habitat and gene pool protection	Pest and disease control	Soil formation and composition	Water conditions	Atmospheric composition and climate regulation	Physical and experiential interactions with biota, ecosystems, and landscapes	Intellectual and representational interactions with biota, ecosystems, and landscapes	Spiritual and/or emblematic interactions with biota, ecosystems, and landscapes	Other cultural outputs
Baited and unbaited trapping	0.7			0.1			0.5	0.6	1.0	0.2		1.1	0.9		0.7		1.0	0.8	0.5	
Seine fishing/ seining	0.4			0.2			0.4	0.5	0.9	0.1		0.6	0.8		0.5		0.7	0.9	0.3	
Temporary drainage	0.8			0.1			0.7	0.6	0.9	0.0		0.6	1.2		0.6		0.8	0.5	0.4	
Biological control agent: indigenous predatory fish	0.5			0.2			0.5	0.6	0.9	0.2		0.8	0.5		0.5		1.0	0.7	0.7	

Overall reliability (95% interval):  $0,79 < ICC(2,k) < 0,88$

# Matrices



Average 5 years	Provisioning						Regulation and maintenance										Cultural			
	Nutrition : biomass	Nutrition : water	Materials : biomass	Materials : water	Biomass-based energy sources	Mechanical energy	Mediation by biota	Mediation by ecosystems	Mediation of mass flows	Mediation of liquid flows	Mediation of gaseous / air flows	Lifecycle maintenance, habitat and gene pool protection	Pest and disease control	Soil formation and composition	Water conditions	Atmospheric composition and climate regulation	Physical and experiential interactions with biota, ecosystems, and landscapes	Intellectual and representational interactions with biota, ecosystems, and landscapes	Spiritual and/or emblematic interactions with biota, ecosystems, and landscapes	Other cultural outputs
Baited and unbaited trapping	0.7			0.1			0.5	0.6	1.0	0.2		1.1	0.9		0.7		1.0	0.8	0.5	
Seine fishing/ seining	0.4			0.2			0.4	0.5	0.9	0.1		0.6	0.8		0.5		0.7	0.9	0.3	
Temporary drainage	0.8			0.1			0.7	0.6	0.9	0.0		0.6	1.2		0.6		0.8	0.5	0.4	
Biological control agent: indigenous predatory fish	0.5			0.2			0.5	0.6	0.9	0.2		0.8	0.5		0.5		1.0	0.7	0.7	

Overall reliability (95% interval):  $0,79 < ICC(2,k) < 0,88$

## Take Home Message

- Balance to be found between **realistic expert evaluation** and **precision**
- Most ecosystem services are altered during plant control actions...  
... but not for crayfish
- After 5 years most actions have positive effects !



# Thank you for your attention !

