Productive capacity of fish habitats in rivers
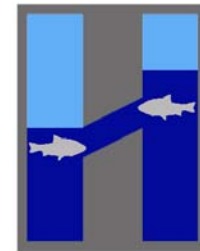
No Net Loss of PCFH:

$$\text{Predict Productive Capacity}_{after}$$

$$-$$

$$\text{Estimate Productive Capacity}_{before}$$

$$\text{Impact of a perturbation}^*$$

* Should be zero to achieve 'no net loss'

General objectives:

1) Improve procedures to **estimate metrics** of PCFH

2) Contribute to the development of **modeling tools** to predict metrics of PCFH

3) Facilitate the implementation of the **principle of NNL** of PCFH

Metrics of PCFH

- Production rate

- Biomass   x   Growth

- Abundance x Mass x Growth

- Recruitment x Survival x Mass x Growth

Metrics of PCFH

- Production rate

- **Biomass** x **Growth**
  <mark>by sp and size classes</mark> <mark>for few species</mark>

- **Abundance** x Mass x Growth
  <mark>by sp and size classes</mark>

- Recruitment x Survival x Mass x Growth

General objectives:

1) Improve procedures to **estimate metrics** of PCFH (Macnaughton et al., in prep)

…need to use both electrofishing and snorkelling surveys to assess fish abundance and biomass in HydroNet rivers…
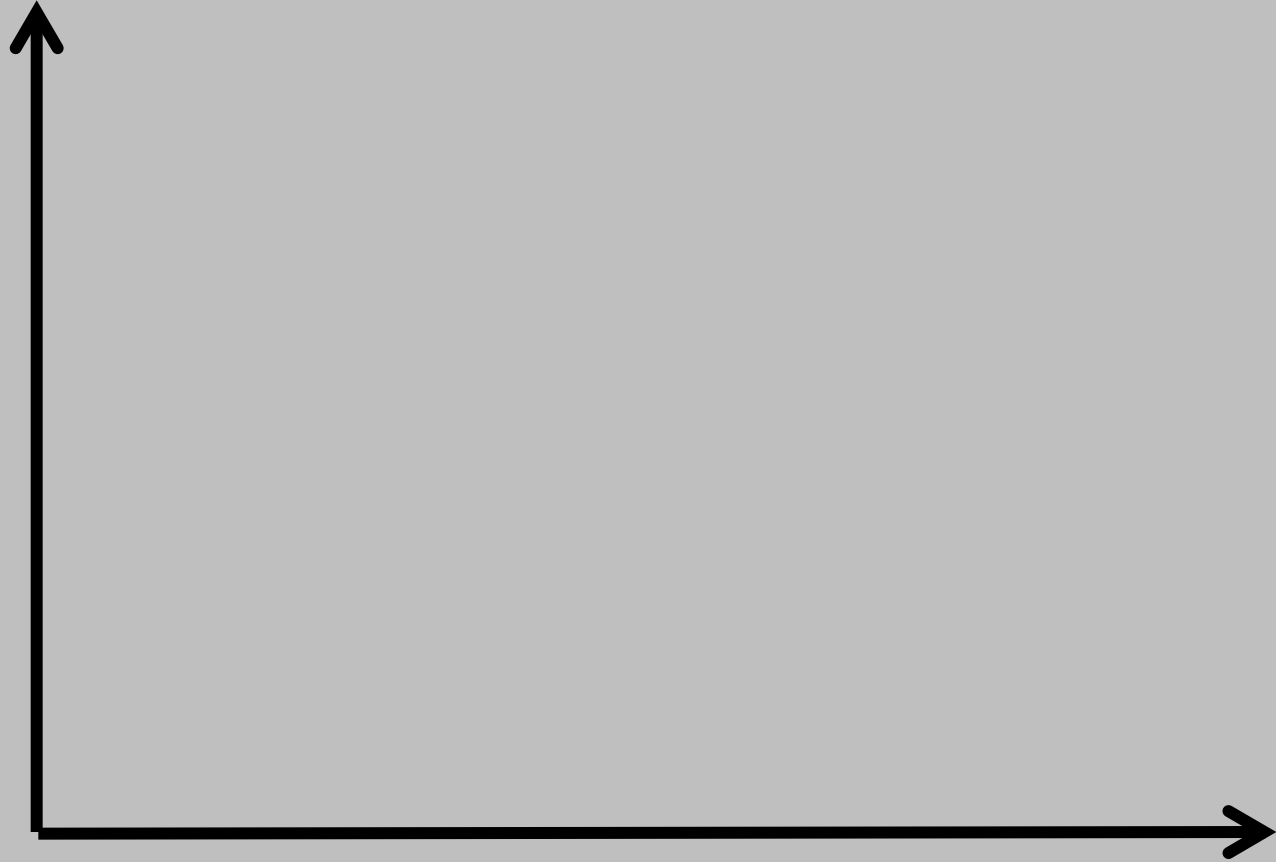
Modeling tools

Macrohabitat
(river segment)

Mesohabitat
(habitat patches)

Microhabitat
(individual territory)

Mecanistic

Empirical

Modeling tools

Macrohabitat
(among river segments)

Mesohabitat
(among habitat patches;
within river)

Microhabitat
(individual territory)

Abundance
Biomass

..…….....Growth…………….

Abundance
Biomass

Mecanistic   **Empirical**
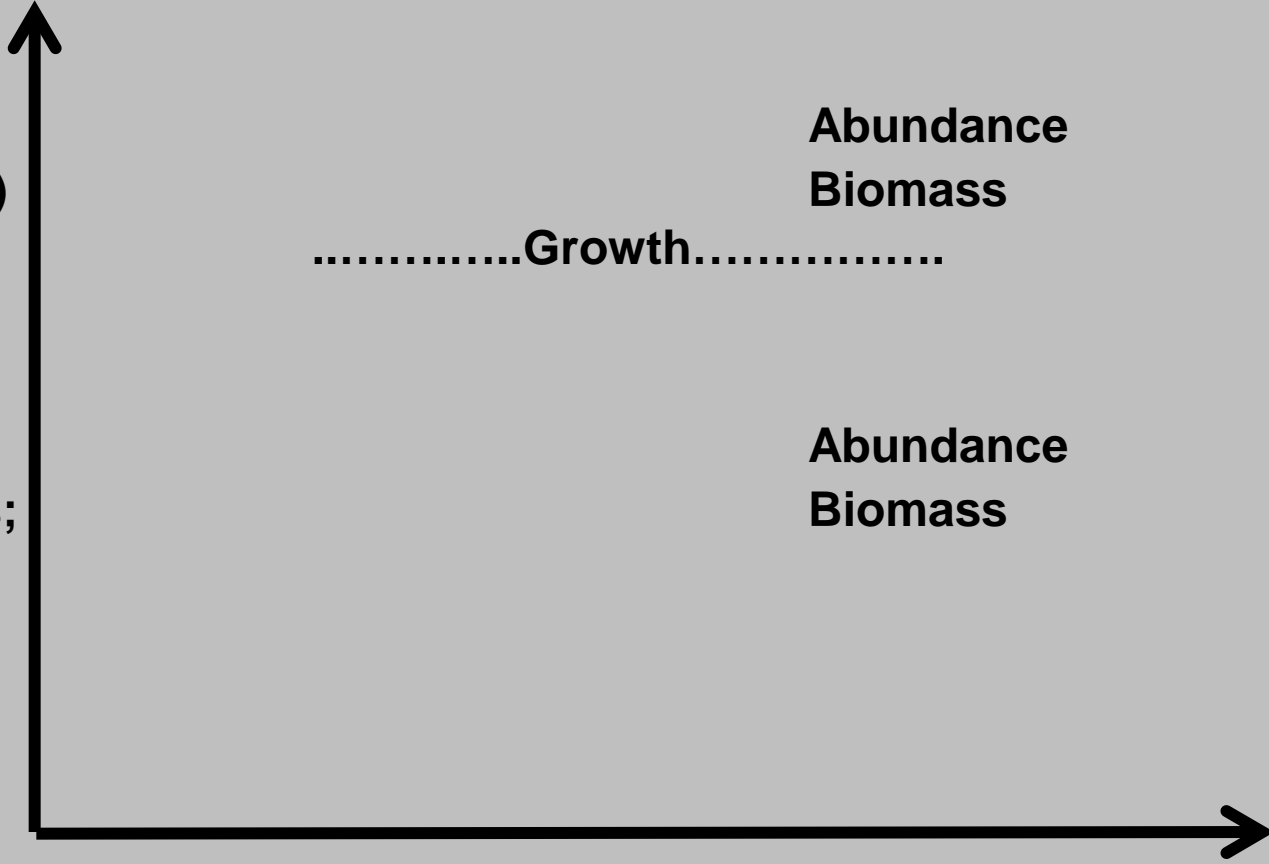
NETWORKING PROJECT (RIVER)
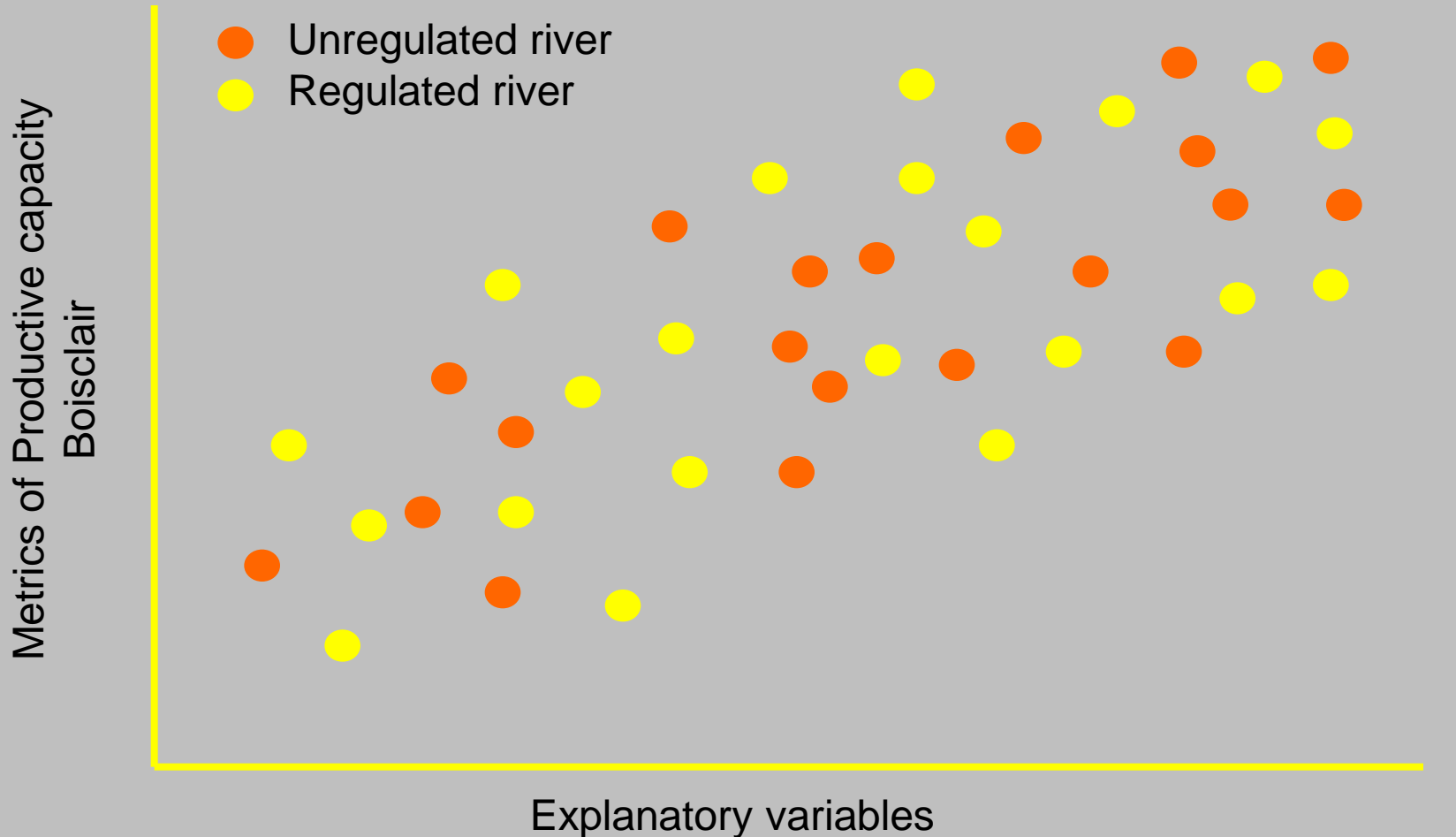
Metrics of Productive capacity Boisclair (y-axis)

Explanatory variables (x-axis)

Legend:
- Unregulated river (orange)
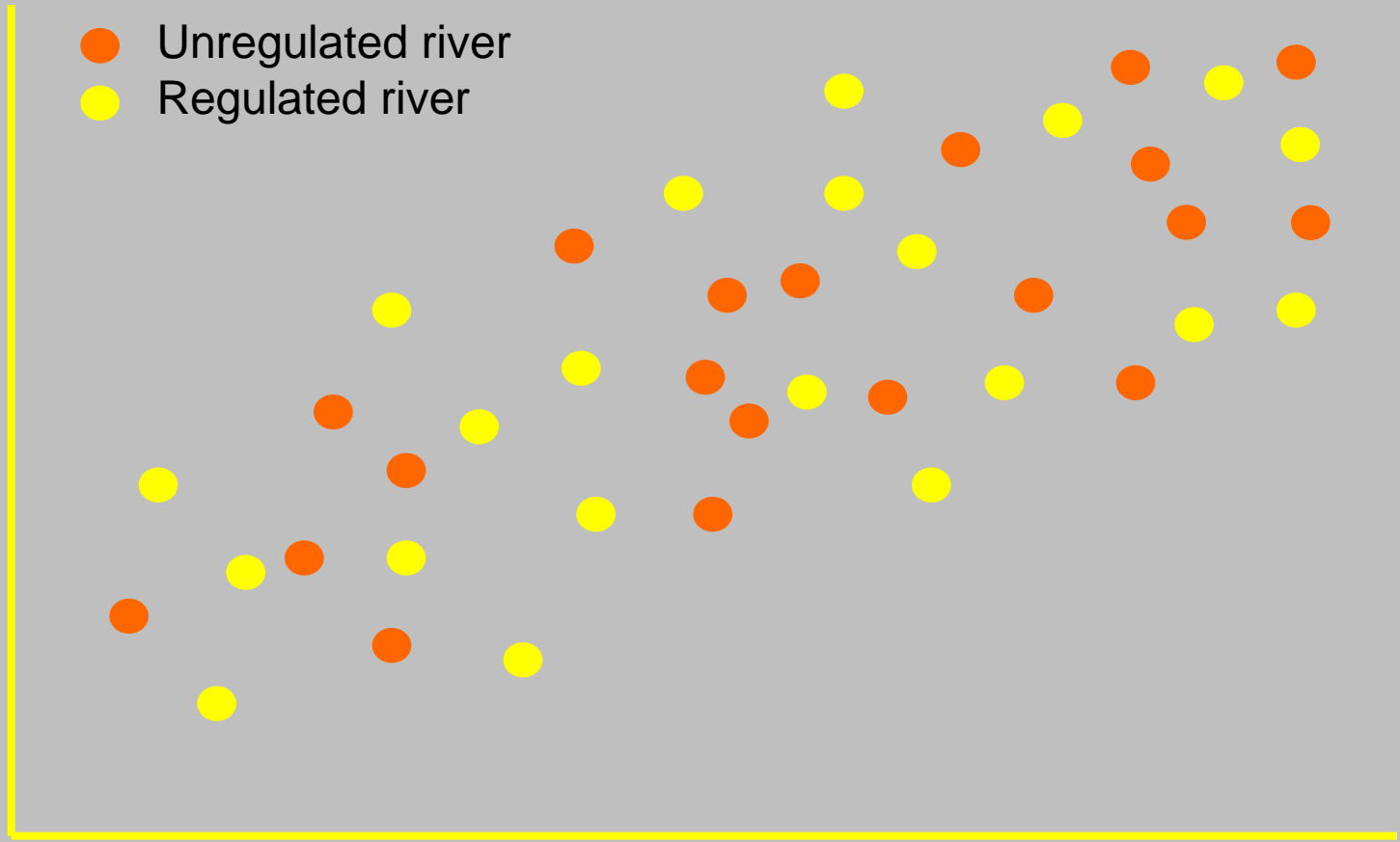- Regulated river (yellow)

TN, TP, DIC (Rasmussen)
Flow characteristics (Lapointe, Boisclair)
Thermal regime (Saint-Hilaire, Bergeron)
Habitat heterogeneity (Boisclair)

Geomorphological setting (Lapointe, Eaton)
Ice conditions (Hicks, Loewen)
Trophic structure (Rasmussen)

NETWORKING PROJECT (RIVER)

Biomass/Abundance by sp and size clases Boisclair

Explanatory variables

- Unregulated river
- Regulated river

TN, TP, DIC (Rasmussen)
Flow characteristics (Lapointe, Boisclair)
Thermal regime (Saint-Hilaire, Bergeron)
Habitat heterogeneity (Boisclair)

Geomorphological setting (Lapointe, Eaton)
Ice conditions (Hicks, Loewen)
Trophic structure (Rasmussen)

PH D PROJECT OF CAMILLE MACNAUGHTON

Fish growth (y-axis)

- 🟠 Unregulated river
- 🟡 Regulated river

Key question:
What is the interaction between fish growth, flow regime, and thermal regime?

Explanatory variables

TN, TP, DIC (Rasmussen)
Flow characteristics (Lapointe, Boisclair)
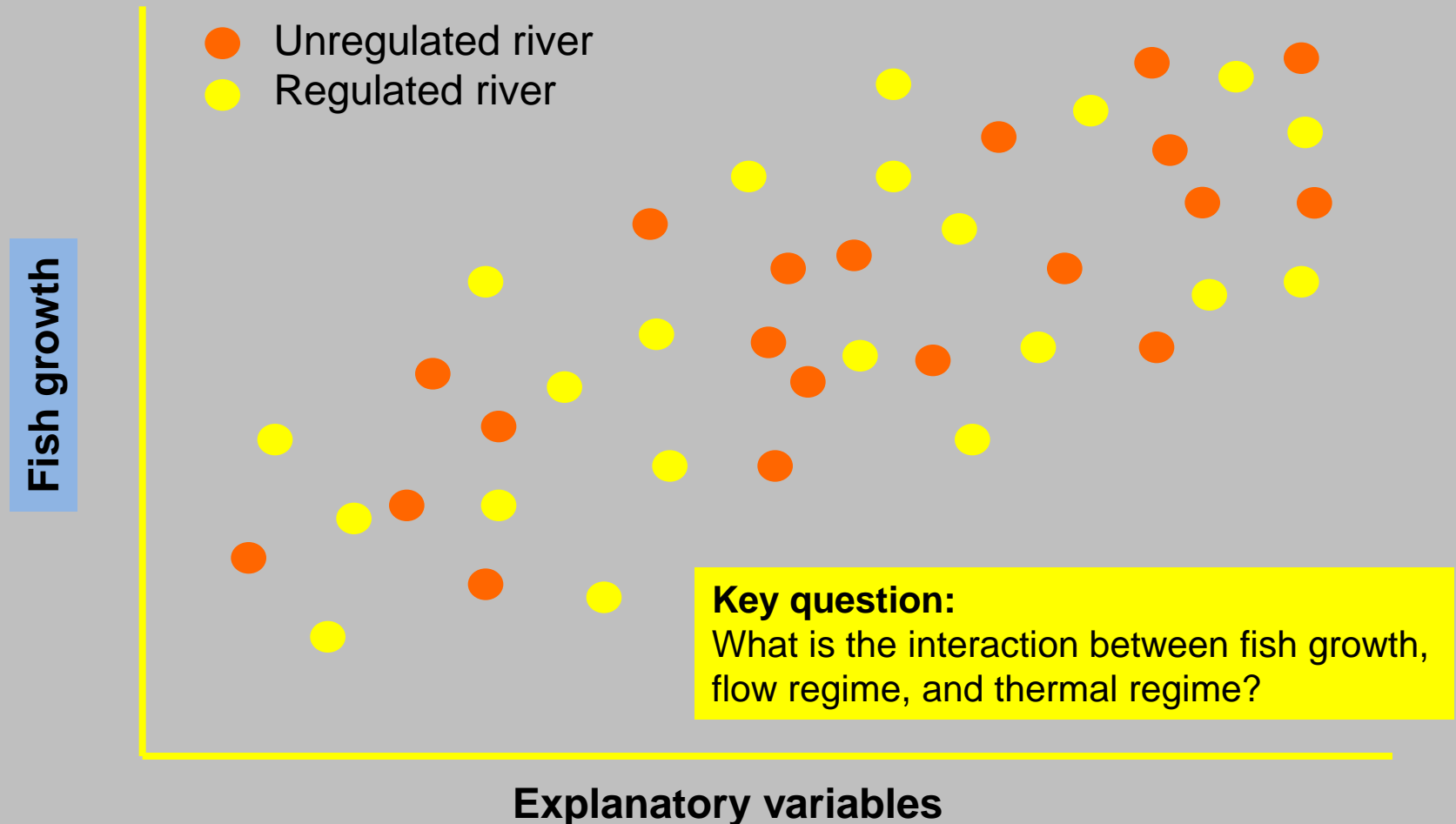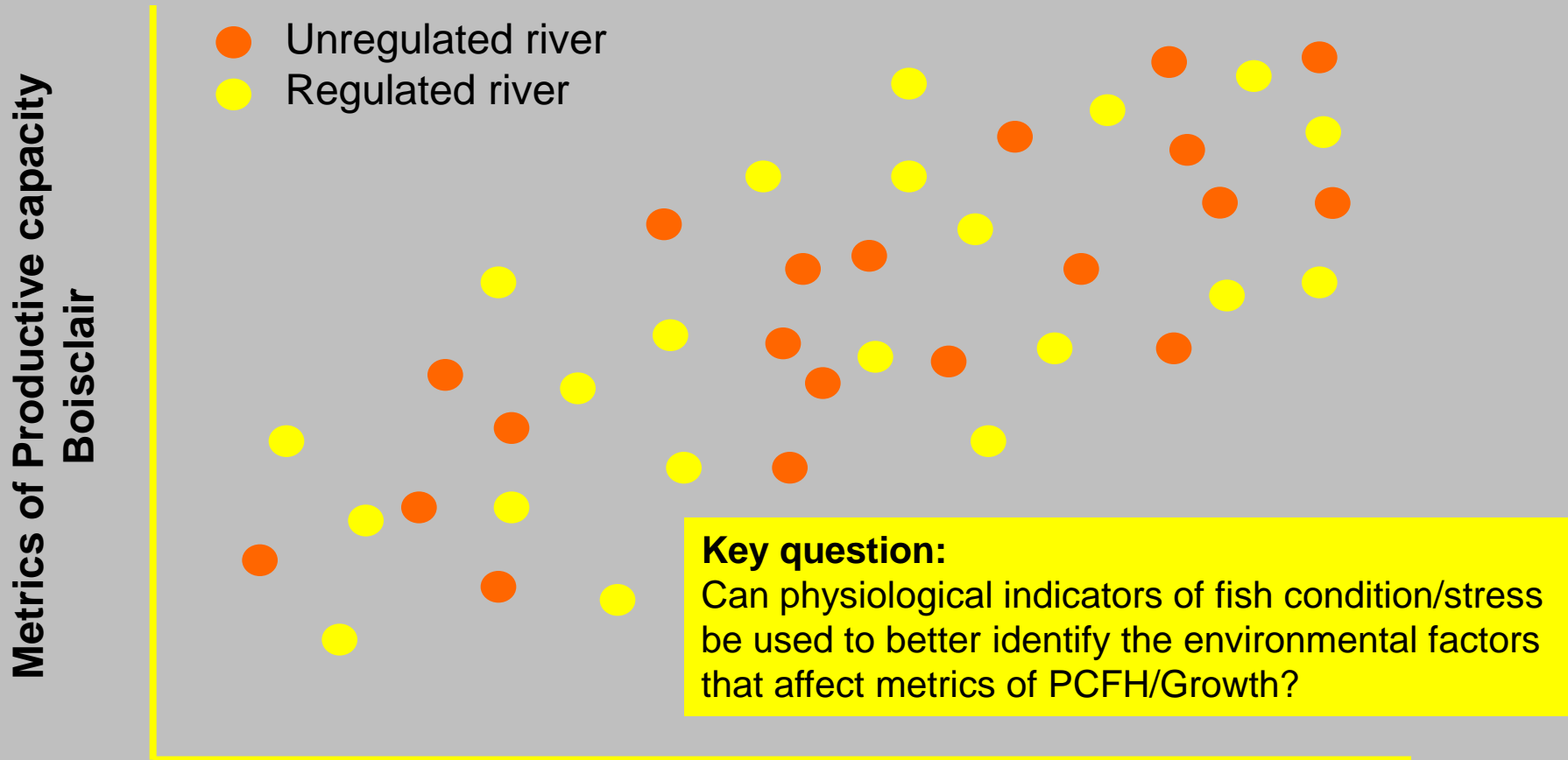**Thermal regime (Saint-Hilaire, Bergeron)**
Habitat heterogeneity (Boisclair)

Geomorphological setting (Lapointe, Eaton)
Ice conditions (Hicks, Loewen)
Trophic structure (Rasmussen)

PH D PROJECT OF SIMONNE HARVEY-LAVOIE

Scatter plot with axes "Metrics of Productive capacity Boisclair" (y-axis) and "Explanatory variables" (x-axis). Legend: orange = Unregulated river, yellow = Regulated river.

Key question:
Can physiological indicators of fish condition/stress be used to better identify the environmental factors that affect metrics of PCFH/Growth?
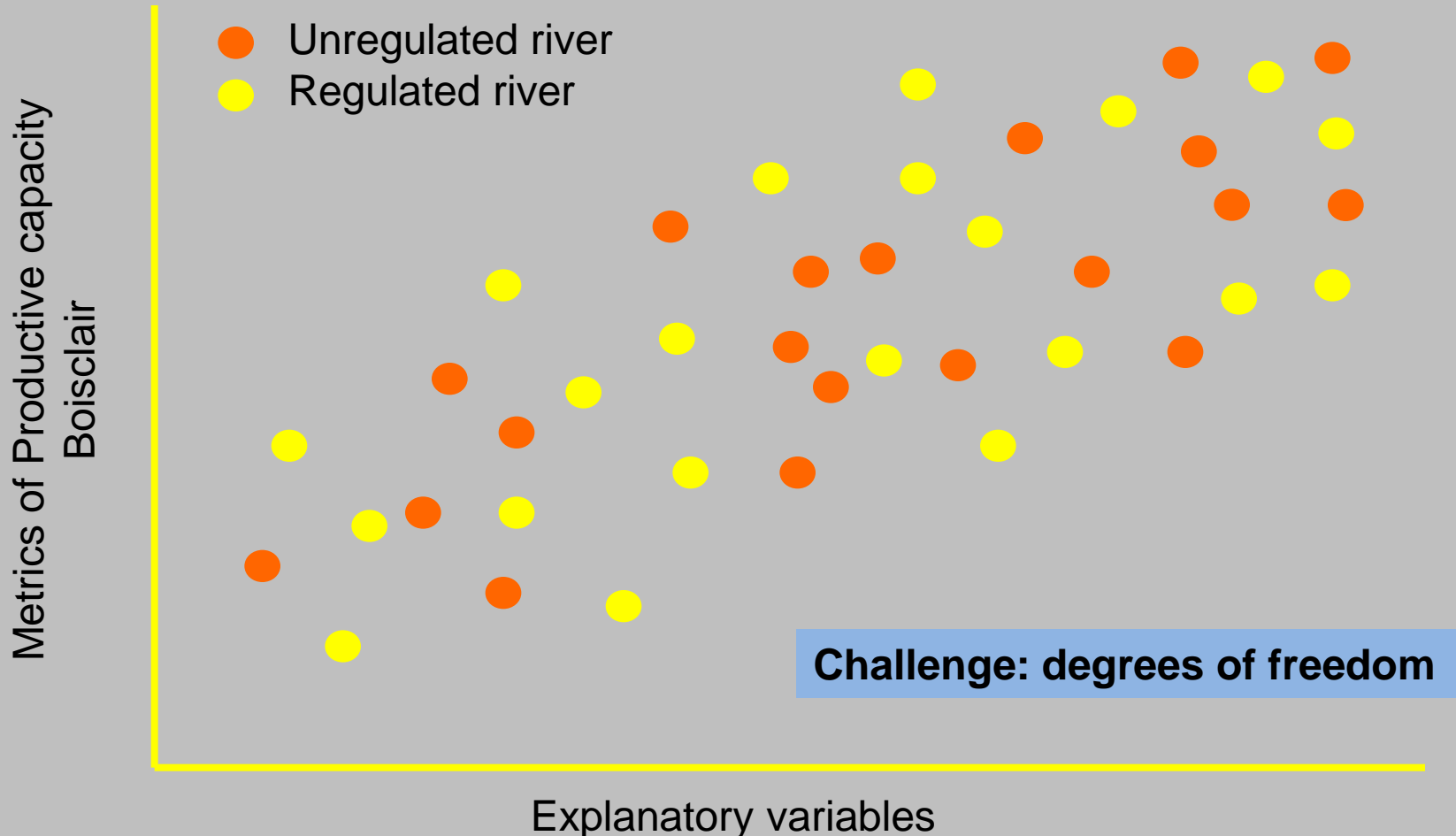
Explanatory variables

TN, TP, DIC (Rasmussen)
Flow characteristics (Lapointe, Boisclair)
Thermal regime (Saint-Hilaire, Bergeron)
Habitat heterogeneity (Boisclair)

Geomorphological setting (Lapointe, Eaton)
Ice conditions (Hicks, Loewen)
Trophic structure (Rasmussen)

NETWORKING PROJECT (RIVER)

Metrics of Productive capacity
Boisclair

- Unregulated river
- Regulated river

Challenge: degrees of freedom

Explanatory variables

TN, TP, DIC (Rasmussen)
Flow characteristics (Lapointe, Boisclair)
Thermal regime (Saint-Hilaire, Bergeron)
Habitat heterogeneity (Boisclair)

Geomorphological setting (Lapointe, Eaton)
Ice conditions (Hicks, Loewen)
Trophic structure (Rasmussen)

>200 indices have been proposed to describe of flow rates:

Colwell, 1974; Hughes and James, 1989; Poff and Ward, 1989; Richards, 1989, 1990; Poff, 1996; Richter et al., 1996, 1997, 1998; Puckridge et al., 1998; Clausen and Biggs, 1997, 2000; Wood et al., 2000; Clausen et al., 2000; McKinney et al., 2001; Lundquist and Cayan, 2002 Olden and Poff, 2003; Baker et al., 2004
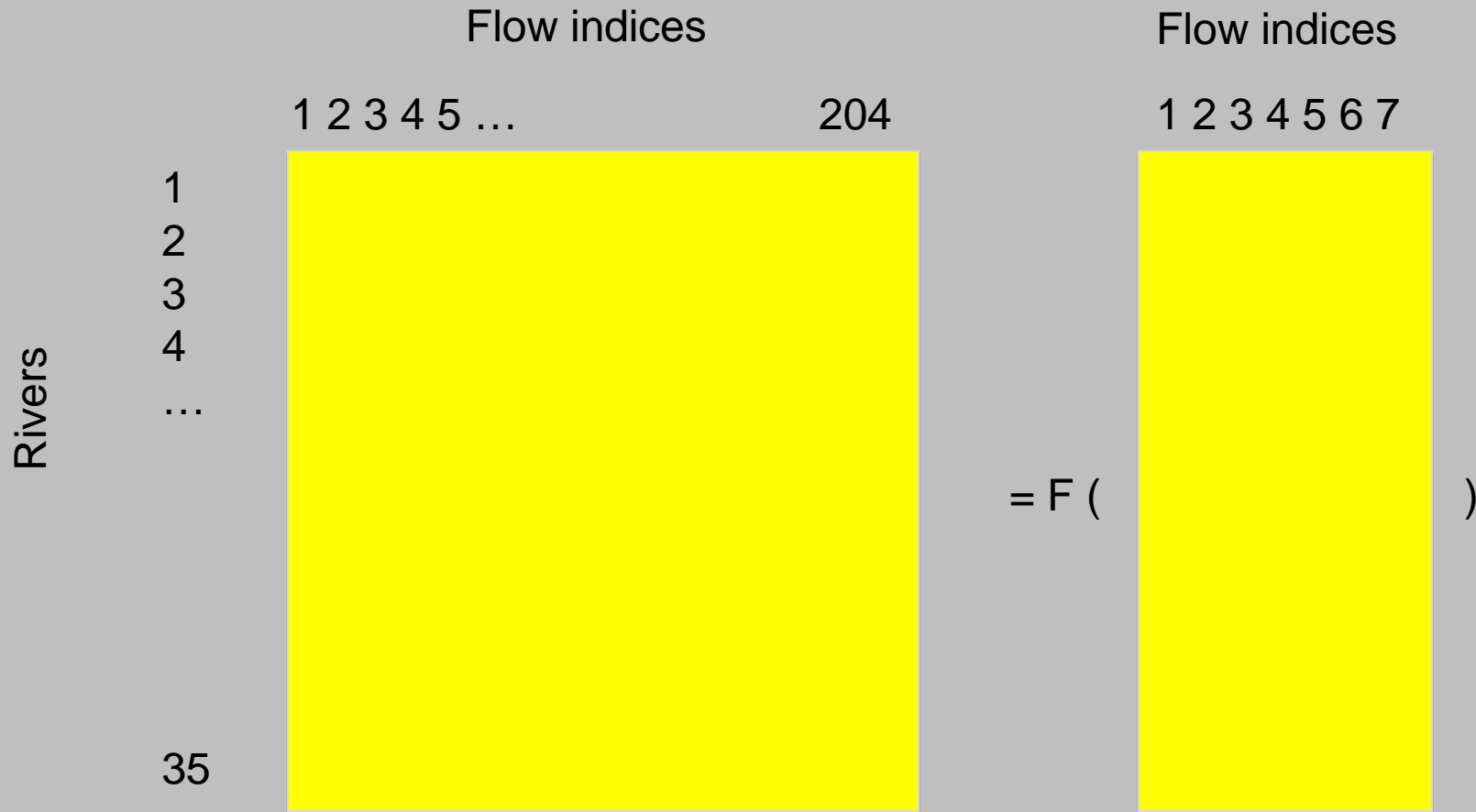
>200 indices have been proposed to describe of flow rates:

Colwell, 1974; Hughes and James, 1989; Poff and Ward, 1989; Richards, 1989, 1990; Poff, 1996; Richter et al., 1996, 1997, 1998; Puckridge et al., 1998; Clausen and Biggs, 1997, 2000; Wood et al., 2000; Clausen et al., 2000; McKinney et al., 2001; Lundquist and Cayan, 2002 Olden and Poff, 2003; Baker et al., 2004

…but the relationship between any of these flow indices and metrics of PCFH remains poorly understood.
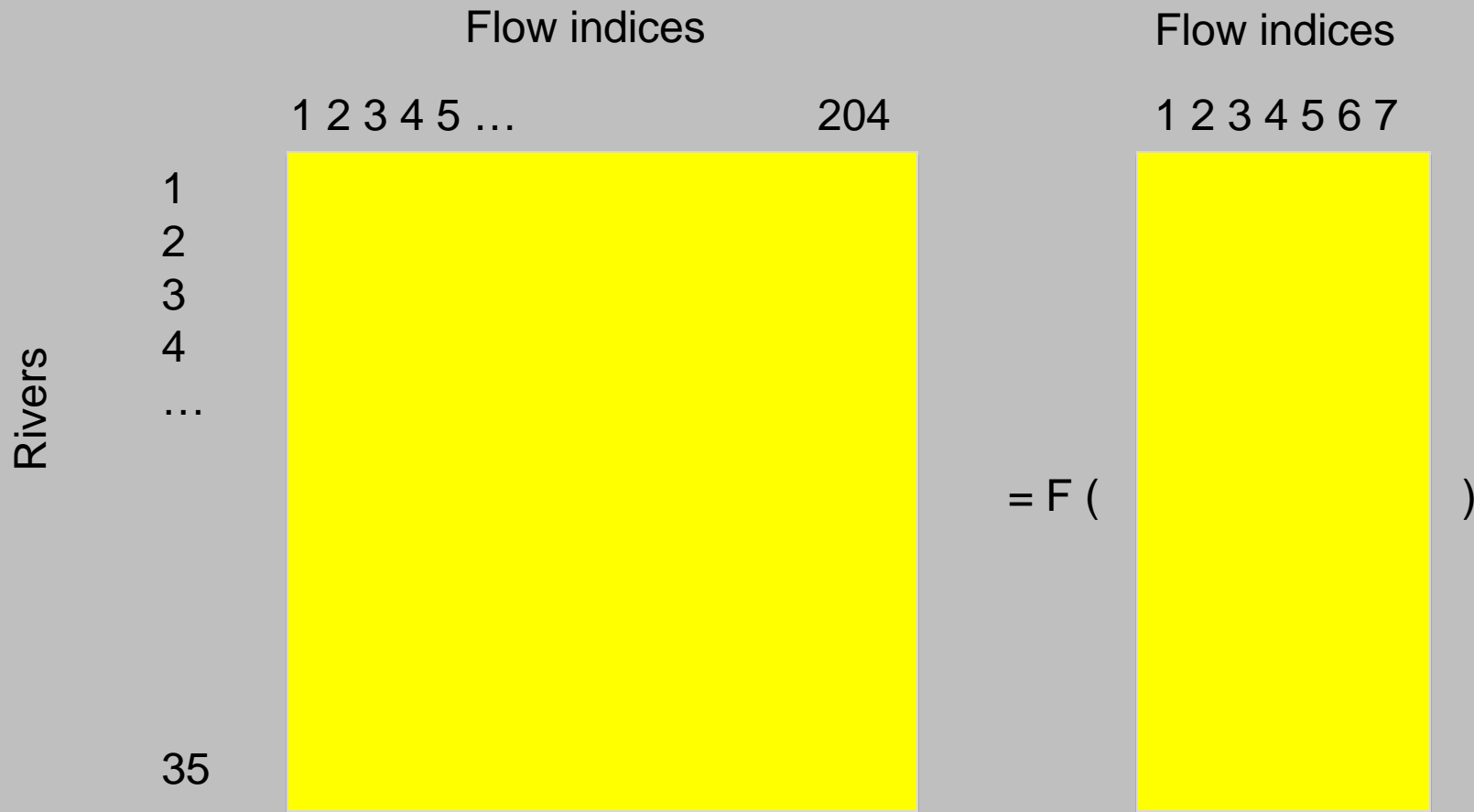
Test of this hypothesis

Canonical Correspondence Analysis

Flow indices

Flow indices

1 2 3 4 5 …   204

1 2 3 4 5 6 7

Rivers

1
2
3
4
…

35

= F (   )

Test of this hypothesis

Canonical Correspondence Analysis

Flow indices

1 2 3 4 5 …   204

Flow indices

1 2 3 4 5 6 7

Rivers

1
2
3
4
…

35

= F (   )

The 7 flow indices explained 75% of the variations in the remaining 204 flow indices

General objectives:

2) Contribute to the development of **modeling tools** to predict metrics of PCFH

…there may be numerous challenges, but it may be possible to develop relationships between metrics of PCFH and environmental conditions affected by hydropower…

Implementation of the principle of NNL

- **Knowledge**

- **Tool**

Knowledge:

- What environmental conditions contribute to explain among-ecosystem variations of metrics of PCFH?

Tool:

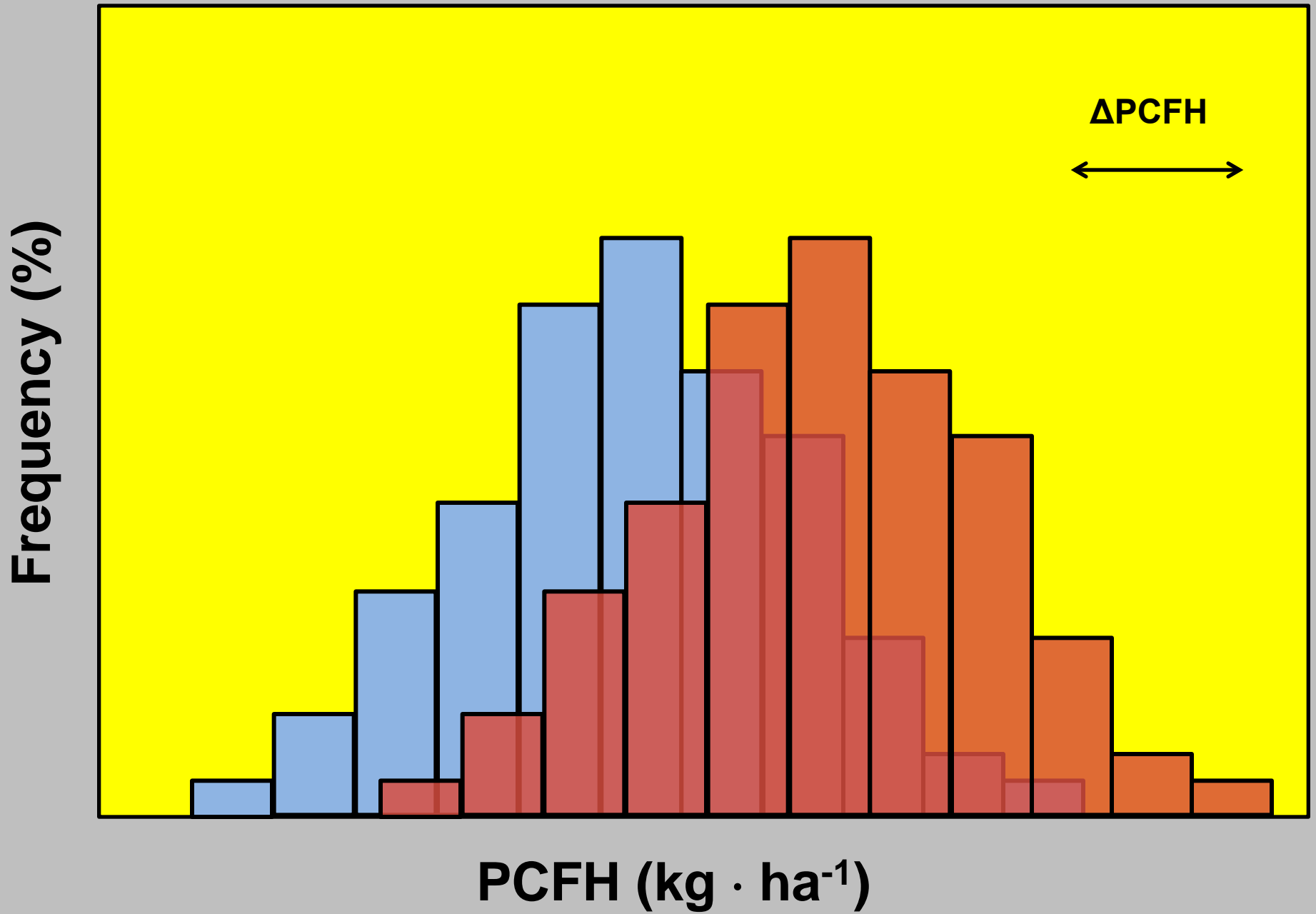- PCFH = $a \cdot Env1^b + c \cdot Env2^d + e \cdot Env3^f + g$

Knowledge:

- What environmental conditions contribute to explain among-ecosystem variations of PCFH?

Tool:

- $PCFH = a \cdot Env1^b + c \cdot Env2^d + e \cdot Env3^f + g$

	Env1	Env2	Env3	PCFH
After	V1b	V2b	V3b	**PCFHa**
Before	V1a	V2a	V3a	**PCFHb**
Effect				**ΔPCFH**

General objectives:

3) Facilitate the implementation of the **principle of NNL** of PCFH

…what environmental conditions are most directly related to PCFH and how…

…what are the anticipated effects of hydropower on PCFH…

…how can we minimize the effects of hydropower on PCFH…

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Gabriel Lanthier, Field Coordinator

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