Managing Mobile Common Pool Resources

Experimental Evidence on Property Rights and Productivity

G. Bayle, **D. Dubois**, M. Beaud, M. Willinger & N. Quérou

CEE-M, CNRS, Univ. Montpellier, INRAE, Institut Agro

CENTER FOR ENVIRONMENTAL ECONOMICS – MONTPELLIER

The CramoRes Project

- **CramoRes** is an ANR-funded project
- Objective: study collective management of **mobile common-pool resources** in a **dynamic and spatially structured context**
- Combines theoretical modeling, experimental economics and behavioral analysis

Common Theoretical Framework

- **Discrete spatial domain**: multiple patches (e.g. A and B)
- **Discrete time**, finite horizon
- **Resource growth** is local
- **Resource mobility**: fraction of stock migrates between patches
- **Terminal condition**: unharvested resource is lost at the end

> This framework derives from Costello, Quérou & Tomini (2015)
> *Partial Enclosure of the Commons*, JPubE

Research questions

- **Mobility**: How does the degree of inter-patch mobility affect management efficiency? *(Project 1)*
- **Governance structure**: Is it better to allocate rights to one or multiple managers? *(Project 2)*
- **Productivity asymmetry**: Should exclusive rights go to the most productive zones? *(Project 3)*
- **Risk**: What happens when a sudden shock (with some probability) redirects the resource flow permanently? *(Project 4)*

Focus on Project 3

Research question

How should **exclusive vs. shared property rights** be allocated in environments with **heterogeneous resource productivity**?

Examples

- **Fisheries**
  Fish stocks move across exclusive economic zones.
  Should rich spawning areas be managed exclusively (e.g. ITQs) or collectively across borders?
- **Transboundary groundwater**
  Aquifers recharge unevenly; water flows across regions.
  Should pumping rights be concentrated in high-recharge zones?
- *Pastoral systems, Forests and wildlife corridors etc.*

> ➤ Where should **exclusive rights** be allocated when **resources are mobile and productivity is uneven**?

Property Rights and Productivity Allocation

We isolate the effect of **productivity allocation**, keeping property rights fixed:

- The **number of players per patch** defines the property regime:
  - **1 player** → Exclusive rights
  - **2 players** → Shared rights
- These rights remain constant throughout the game (1A - 2B)

We manipulate only the **location of high productivity**:

- A_h: high productivity in **exclusive** patch (A)
- B_h: high productivity in **shared** patch (B)

> ➤ Do productive zones perform better under **exclusive or shared** management?

Formal model

- Two interconnected patches: **A** and **B**
- Each patch has a renewable stock: $x_{i,t}$
- Players choose how much to harvest: $h_{i,t}$
- **Resource dynamics** (growth and mobility):

$$x_{i,t+1} = D_{ii} \cdot (1 + \alpha_i)(x_{i,t} - h_{i,t}) + D_{ji} \cdot (1 + \alpha_j)(x_{j,t} - h_{j,t})$$

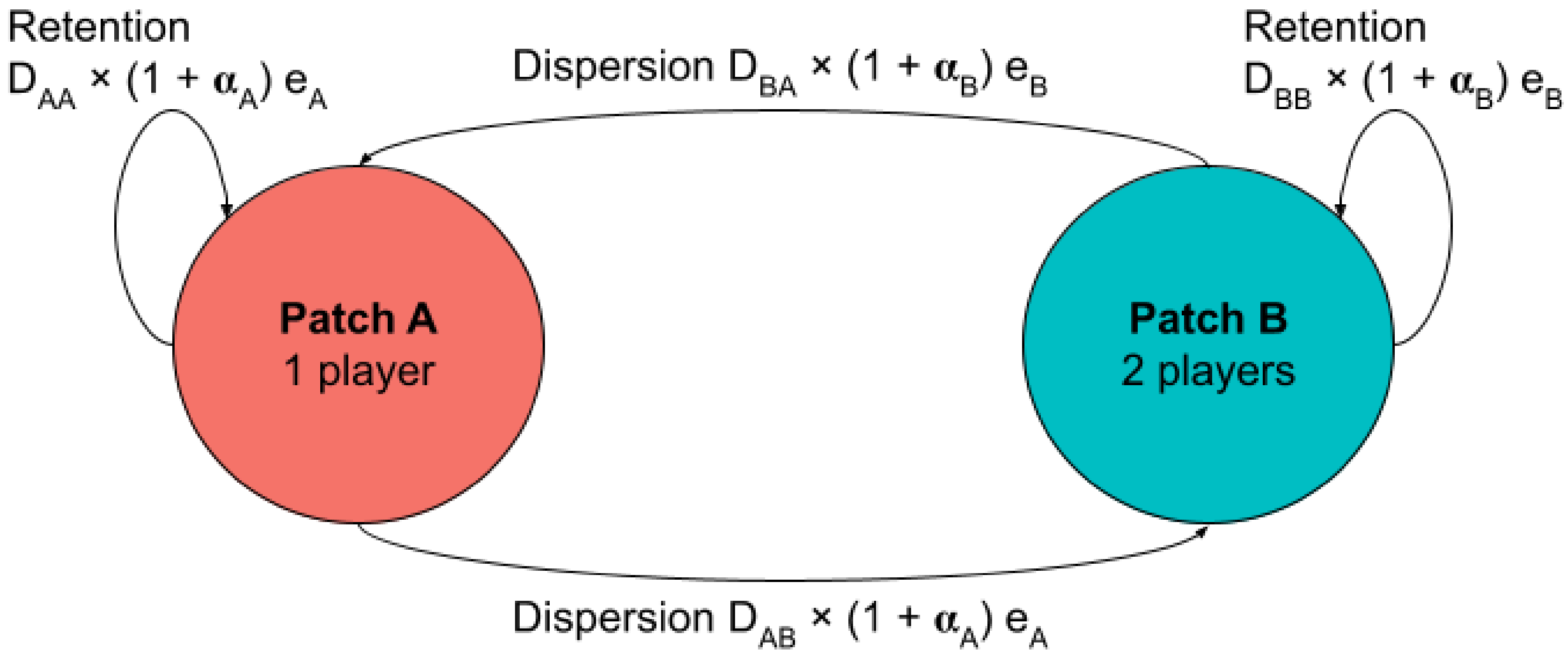
- α_i: growth rate in patch *i*
- D_{ii}: retention, D_{ji}: migration from the other patch (dispersion)
- Payoff: $\pi_{i,t} = p \cdot h_{i,t}$ (no harvest cost, $p = 1$)

Productivity

- Patch productivity: $Q_i = D_{ii} \cdot (1 + \alpha_i)$
- Productivity reflects *the marginal return from conserving one unit in a patch*

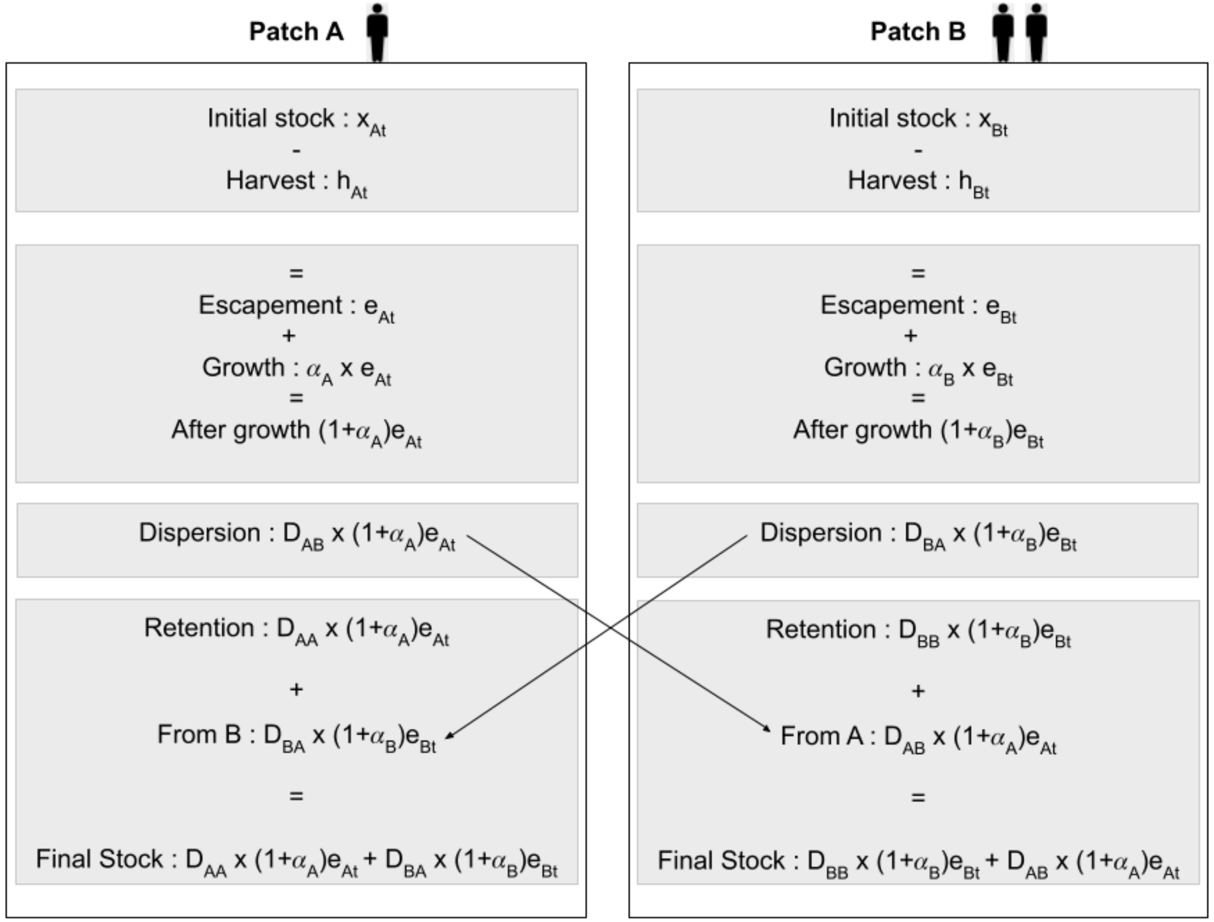
Productivity	Interpretation	Implication
$Q_i > 1$	Keeping the resource is more valuable	**Conserve** the resource
$Q_i < 1$	Extracting now is more profitable	**Harvest immediately**

Illustration (1/2)



$e_i = x_{it} - h_{it}$ = escapement (residual stock)

Illustration (2/2)



$\mathbf{A_h}$: $(1 + \alpha_A) > 1$ and $(1 + \alpha_B) < 1$ $\mathbf{B_h}$: $(1 + \alpha_A) < 1$ and $(1 + \alpha_B) > 1$

Efficient vs. Strategic Extraction

- The **efficient path** maximizes total payoff over time:
  - Players should wait, let the resource grow, then harvest everything in the **last period**
  - No extraction in $t < T$, full harvest in $t = T$
- Under **decentralized (non-cooperative)** behavior:
  - Players anticipate others' overharvesting
  - Leads to **early and excessive extraction**

> Strategic behavior creates an intertemporal dilemma
> → Extract early to preempt rivals and secure payoffs

Impact of Productivity Allocation

- When **high productivity** is managed by a **single player**:
  - She can wait until the last round → behavior close to the efficient path
- When high productivity is managed by **two players**:
  - Lack of coordination → over-extraction from the start
  - Externality affects the other patch through **resource mobility**

Predicted outcome

Treatment	Behavior in high-prod. patch	Efficiency
A_h (exclusive)	Conservation until $t = T$	Higher
B_h (shared)	Early extraction	Lower

> ➤ **Exclusive rights** in high-productivity areas should lead to better resource management

Experimental Setup

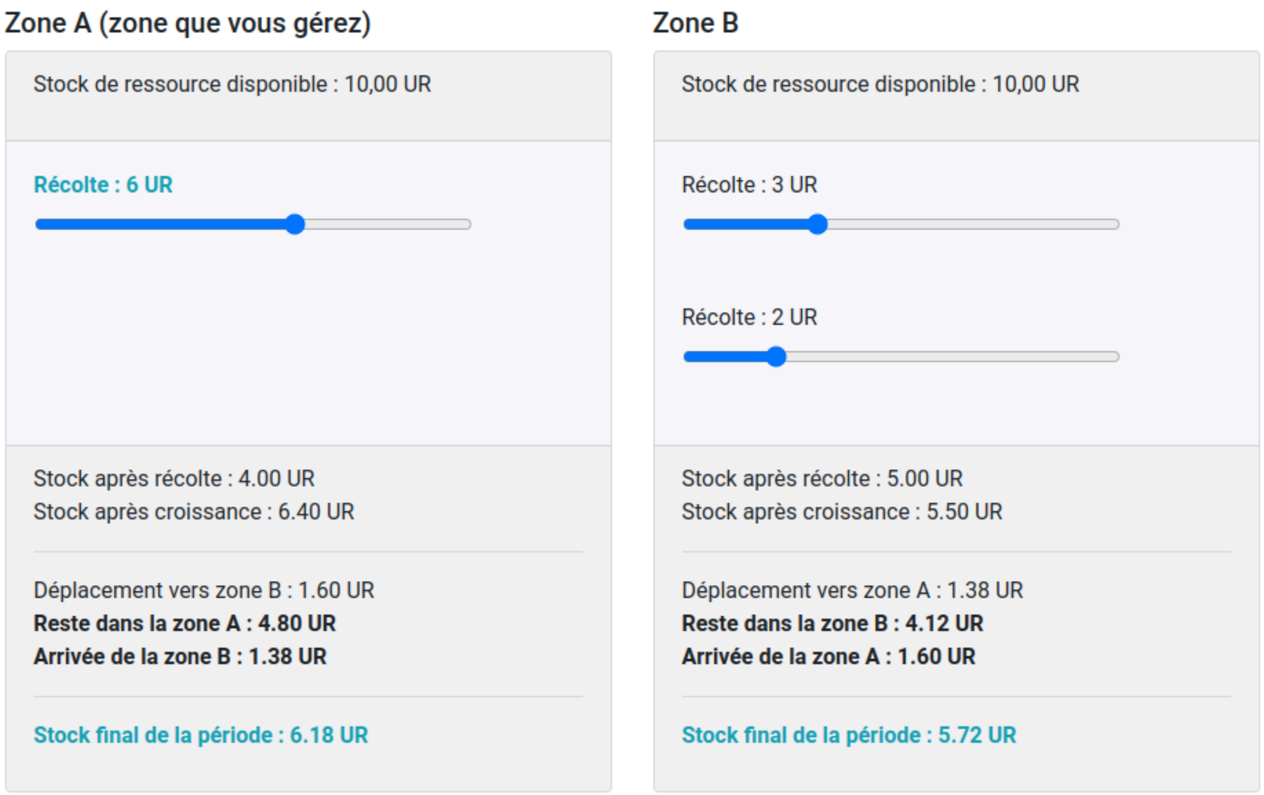
- Laboratory experiment
- Between-subject design with 2 treatments:
  - A_h: high-productivity on patch A
  - B_h: high-productivity on patch B
- 8 rounds per game
- N = 273 participants – A_h: 153, B_h: 120

> *Control tasks: NLE, PGSM, GPS*

Parameters

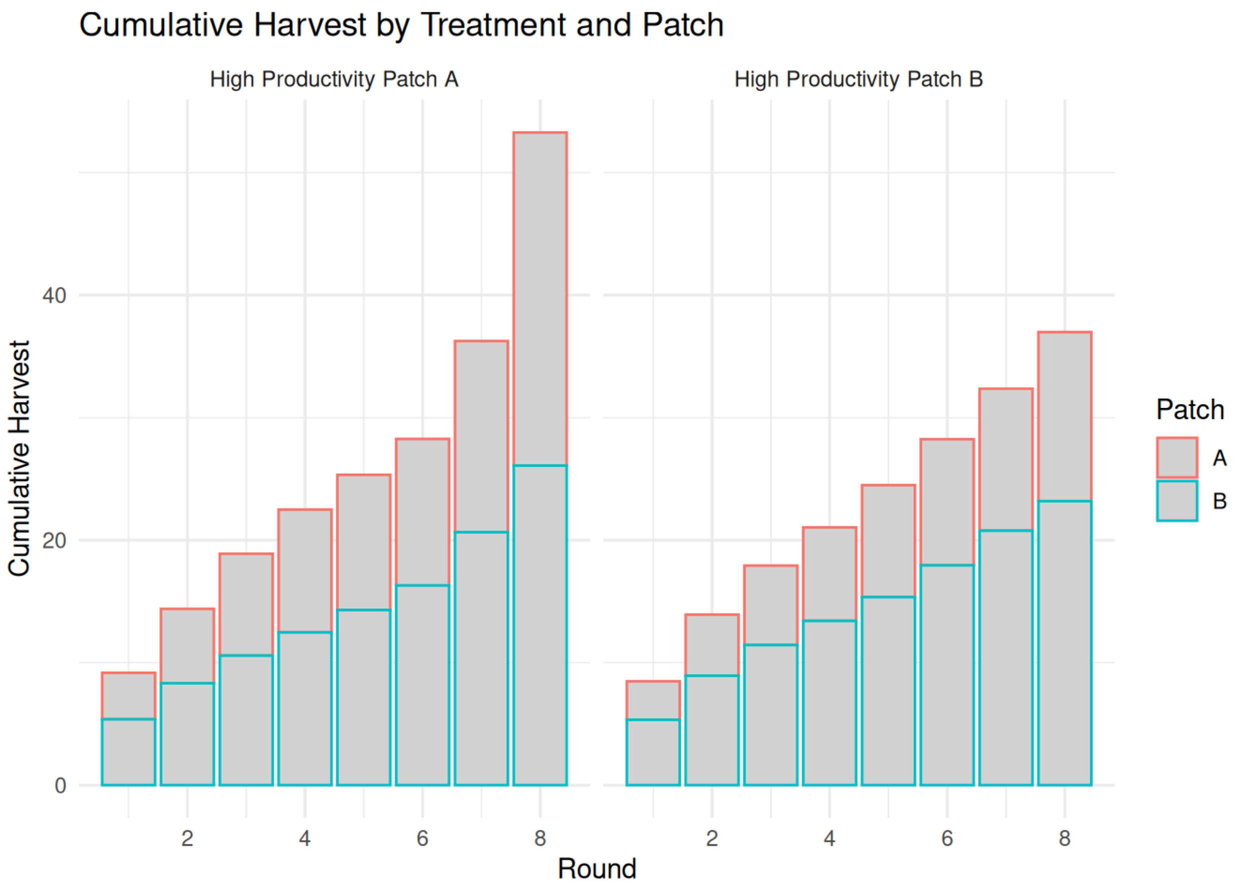
- Initial stock: 10 units per patch
- D_{ii} = 0.75 – **Retention**
- D_{ji} = 0.25 – **Dispersion**
- $(1+\alpha)_h$ = 1.6 – **High** productivity ($Q = 1.6 \cdot 0.75 = 1.2$)
- $(1+\alpha)_l$ = 1.1 – **Low** productivity ($Q = 1.1 \cdot 0.75 = 0.825$)

Decision Interface (Player A)



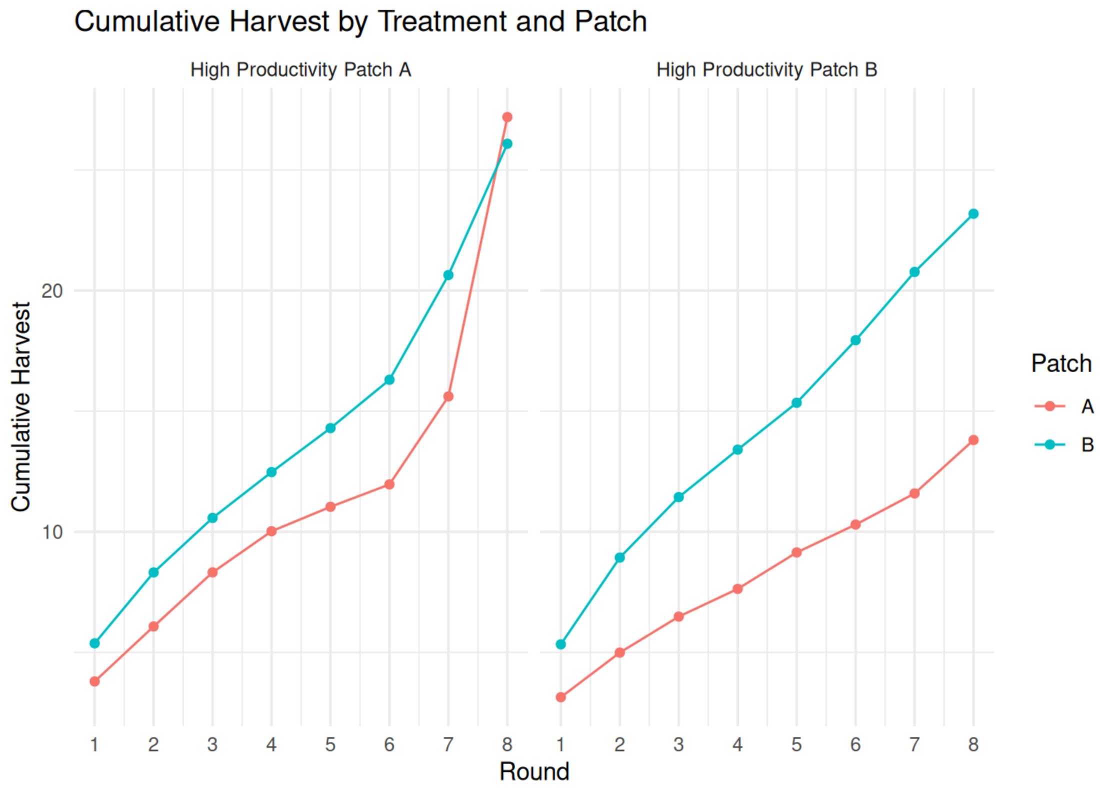
> Only the player's own slider determines their decision. The others simulate teammates' choices.

Cumulative Harvest – Overall Efficiency



Total harvest is **higher in A_h** than in B_h – *Mann-Whitney test p<0.05*

Cumulative Harvest – Distribution by Patch

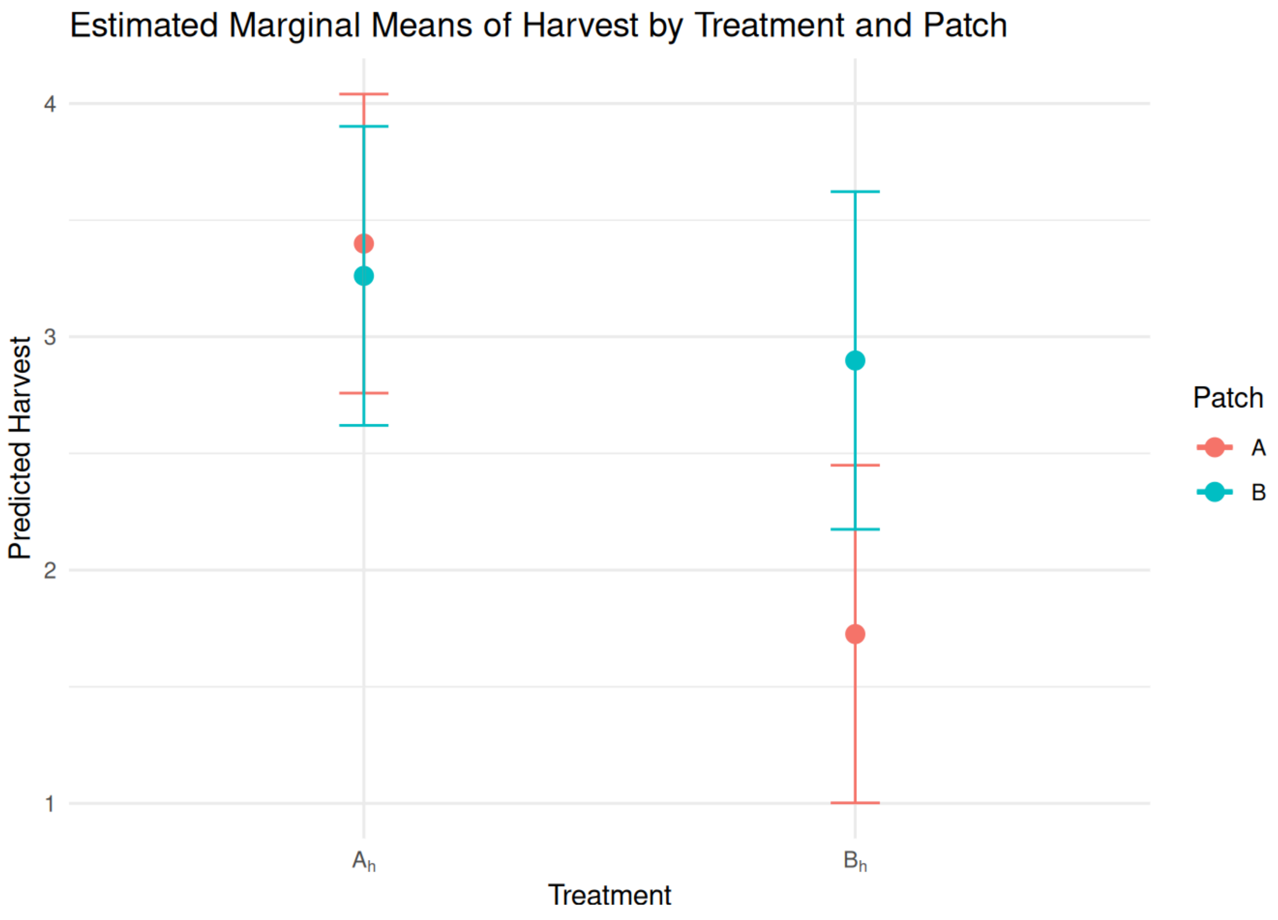


- Players in **Patch B** extract similar quantities in A_h and B_h– *MW test p=0.663*
- In B_h, the player in **Patch A** extracts much less than in A_h – *MW test p<0.001*

Mixed Model

	Harvest
Intercept	2.849***
Treat. B_h	-1.674***
Patch B	-0.138
Round	0.122+
Treat. B_h × Patch B	1.311*

+ p < 0.1, * p < 0.05, ** p < 0.01, *** p < 0.001



- **Intercept**: 2.85 units ($p < 0.001$) of harvest in treatment A_h, Patch A
- **Treatment B_h**: −1.67 units ($p < 0.001$) → Lower harvest when high productivity moves to patch B
- **Patch B**: No significant effect ($p = 0.74$)
- **Treatment × Patch**: +1.31 units ($p = 0.037$) → Negative effect of treatment B_h is **mitigated in patch B** (-1.67 + 1.31 = -0.36)

> ➤ The model suggests that treatment B_h reduces harvest, but this effect is moderated in Patch B, where the reduction is less pronounced.

Conclusion

- Exclusive rights over high-productivity areas **improve overall efficiency**
- Shared management leads to **early extraction and negative spillovers**
- Property rights allocation must consider both **productivity** and **strategic incentives**

> ➤ Insights for designing institutional arrangements in mobile CPRs

Thank you

Contact: dimitri.dubois@umontpellier.fr

Website: https://duboishome.info/dimitri

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Numerical Predictions