The rise of collaborative management partnerships (CMPs) strongly decreased deforestation in initially threatened African protected areas

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Outline

GLOBAL BIODIVERSITY CRISIS

- Biodiversity decline = major global challenge of the 21^{st} century
- Human activities ⇒ modified 75% of terrestrial ecosystems
- Key driver = land use change

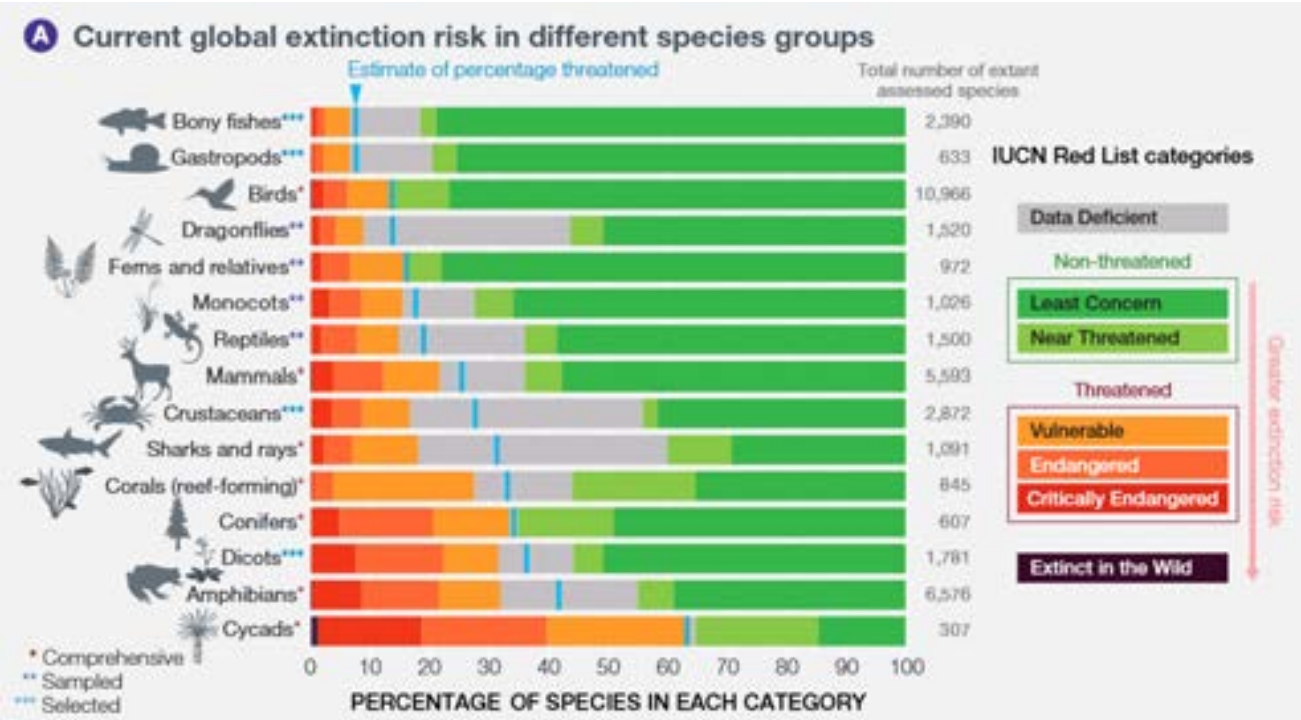

Figure: IPBES (2019)

PROTECTED AREAS (PA)

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- Rich literature since early 2010s: Quantifying the impact of conservation policies
  - Additionality: building a counterfactual scenario of what would have happened without a conservation policy
  - Causality (not always easy): increasing use of modern statistical models

Effectiveness of protected areas (PA)

- Conservation outcomes are better off when specific policies
- Average PA effectiveness $\approx 30\%$
  & highly variable across countries (Neal, 2024)
- Particularly concerning in biodiversity-rich countries with limited resources
- Real challenges in low income countries, including Sub-Saharan Africa (Craigie et al., 2010, Scholte et al.,2022, Meng et al., 2023)

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- Real challenges in low income countries, including Sub-Saharan Africa (Craigie et al., 2010, Scholte et al.,2022, Meng et al., 2023)
- Note: not only a low-income country problem. PAs had no additionality in Europe over the last 40 years (Grupp et al., 2024).

$\Rightarrow$ Need to improve PA management and governance models for sustainable coexistence between humans and other living beings

Key challenges for PAs effectiveness

- Location bias
  - PAs are often "high and far" (Joppa and Pfaff, 2009)
  - Ecosystems with limited initial pressure (e.g. Salonga National Park in the DRC)
- Governance
  - Chronic funding shortages (Lindsey et al., 2018)
  - Limited management capacities (West et al., 2022)
  - Weak institutions and governance (Bonilla-Mejía & Higuera-Mendieta, 2019)
  - Conflict and instability in many regions
- Economics
  - Large dependence on lands for livelihoods (>70% of the population live out of agriculture)
  - Limited alternatives
  - Important barriers to access these opportunities

CONSERVATION IN SSA: NEW ACTORS NEEDED?

- Funding shortages & lack of capacity of states / communities for conservation in poor countries (Lindsey et al., 2021)
- Non-govermental actors (private / NGOs) could fill this gap by bringing founding and capacity through PPPs
- Potential for contractual arrangement with external actors (long-term / contractual / manag. & capacity transfer)
- Context: increasing influence of largest international conservation organizations WWF, WCS, APN...

⇒ Notably the (famous & controversial) *African Parks network* created in 2000, 22 parks (12 countries) in SSA, in 2023

⇒ Only a single study (Denny et al., 2024) on APN

APN

Figure: African Parks network (APN) projects

PPP IN CONSERVATION

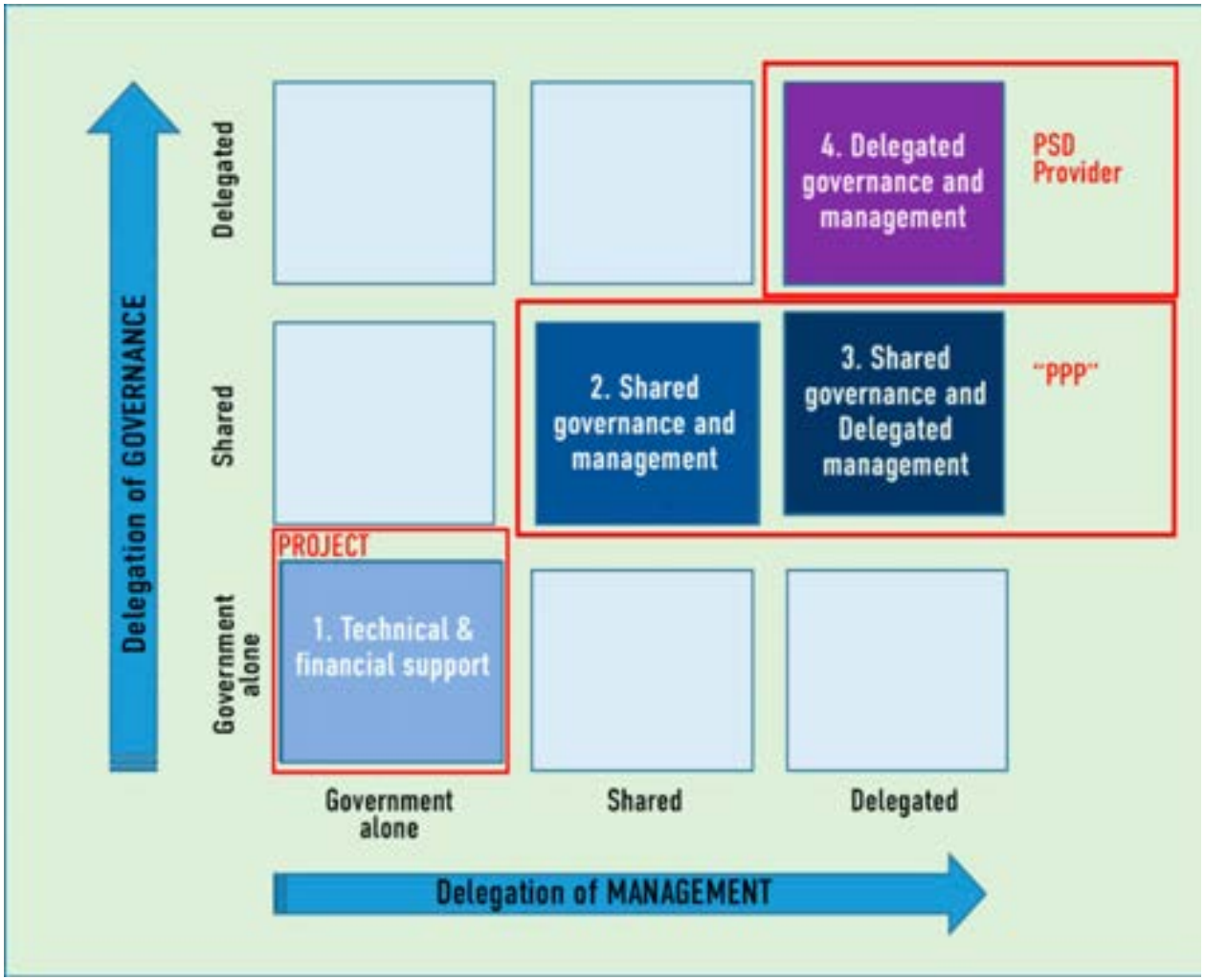
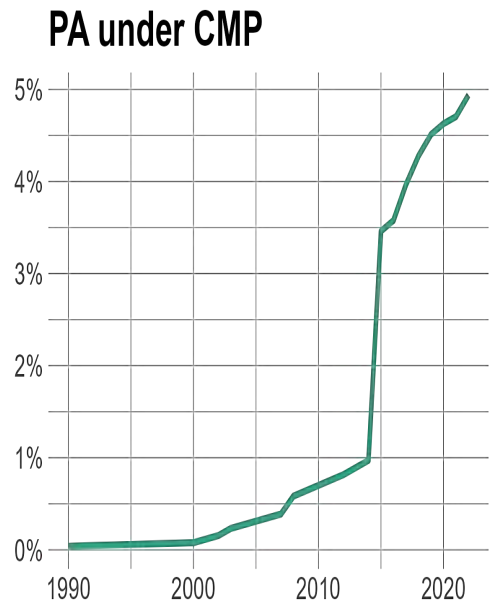


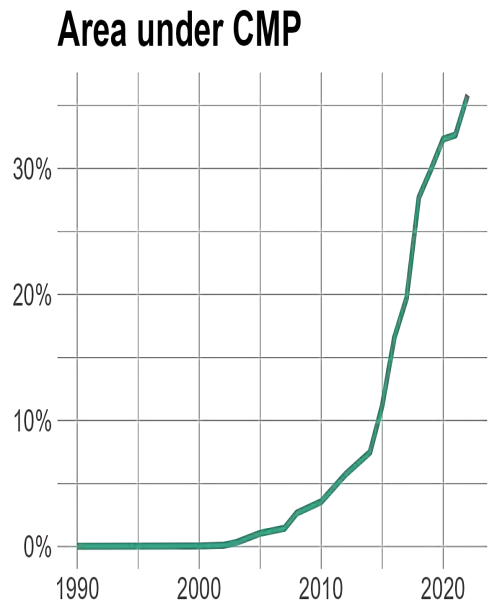
Figure: 4 main types of partnerships between public and a private partners for the management of protected areas, Baghai (2016)

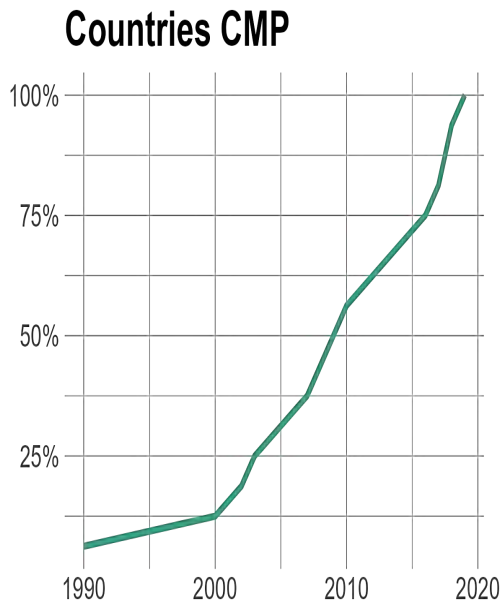
Our paper

- **Count & map** CMPs in SSA
  - First CMP : Kasanka in Zambia, established in 1990
  - 122 terrestrial CMPs (979,387km²) across 16 countries by the end of 2023
  - 48 partner organizations, mostly (international & local) NGOs (1 private sector)
- **Quantify** their (relative) **impact** on **forest loss** (African continent: 2000-2023) as compared to regular PAs

Evolution in Sub-Saharan Africa (SSA)

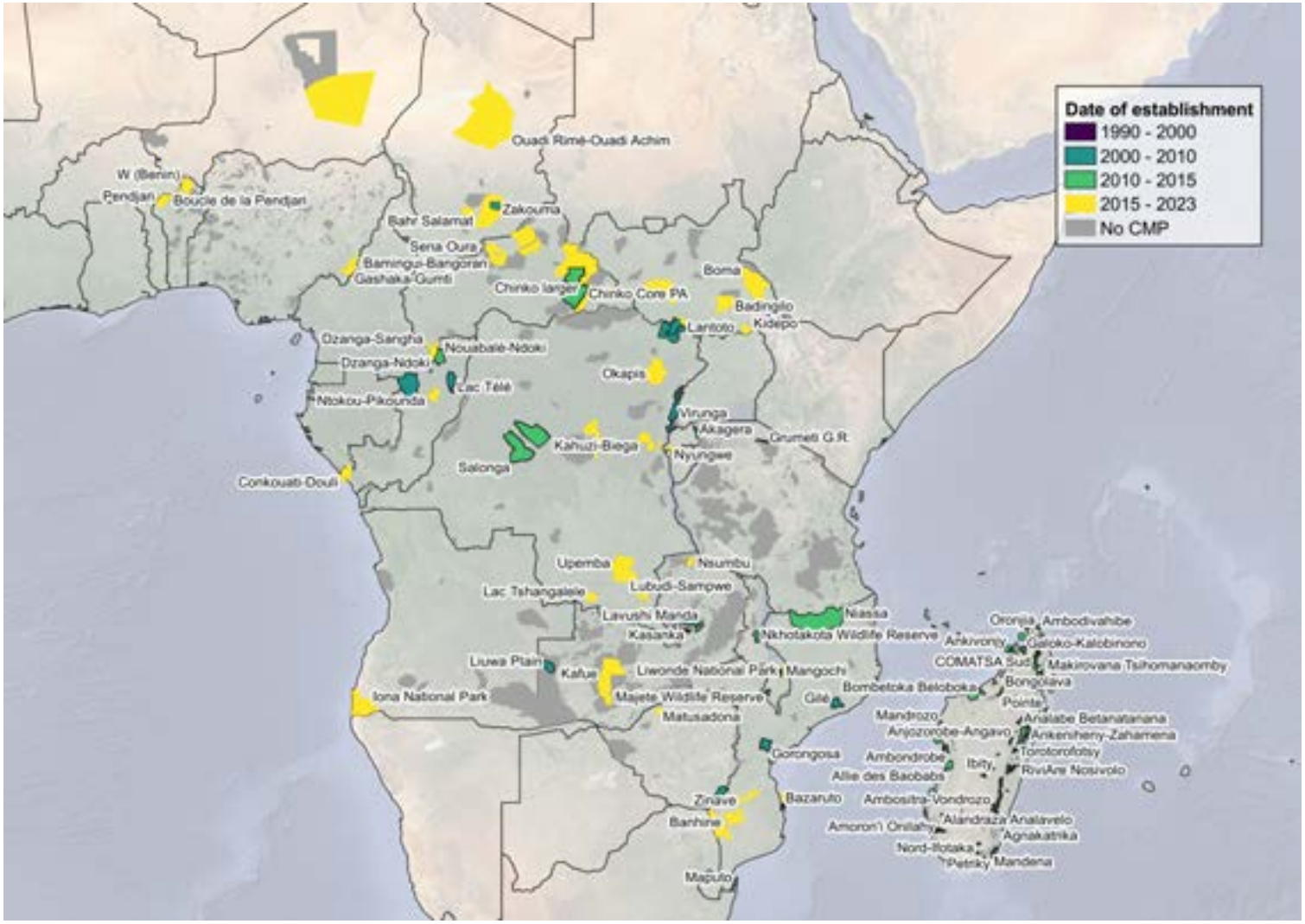






Temporal evolution of CMPs (1990-2020)

COLLABORATIVE MANAGEMENT PARTNERSHIPS



Protected Areas (PAs) under collaborative management partnership (CMP) in Sub-Saharan Africa.

METHODS

- **Treatment**: PAs begins a **CMP** (staggered, de Chaisemartin & d'Haultfœuille, 2024, + Callaway & Sant'Anna)
- **Cell** analysis (5×5km $\rightarrow$ 25km^2), outcome: annual disturbances (Hansen et al., 2013)
- Random sample (1/3)
- **Matching** with regular PAs (991 potential control PAs)
  $\rightarrow$ cell level, same PA designation status & biome,
  $\rightarrow$ in the 16 SSA countries with CMPs (CMPs = 35% of the total area under protection)

DID (BACI) $\Rightarrow$ ATE (& event study)

ROLL-OUT FEATURE OF THE PROGRAM

Table: Year of creation of CMPs

	Freq.	Percent
before 2000	10	7
2000	5	2.99
2002	2	1.2
2003	4	2.4
2005	3	1.8
2006	1	0.6
2007	3	1.8
2008	5	2.99
2010	3	1.8
2011	4	2.4
2012	6	3.59
2013	4	2.4
2014	6	3.59
2015	64	38.32
2016	4	2.4
2017	13	7.78
2018	10	5.99
2019	7	4.19
2020	3	1.8
2021	3	1.8
2022	4	2.4
Total	164	100

$\Rightarrow$ staggered DID estimator on matched cells (17,953 cells of 25km^2) among 99 CMPs, for which matched controls were found

Illustration basic DID

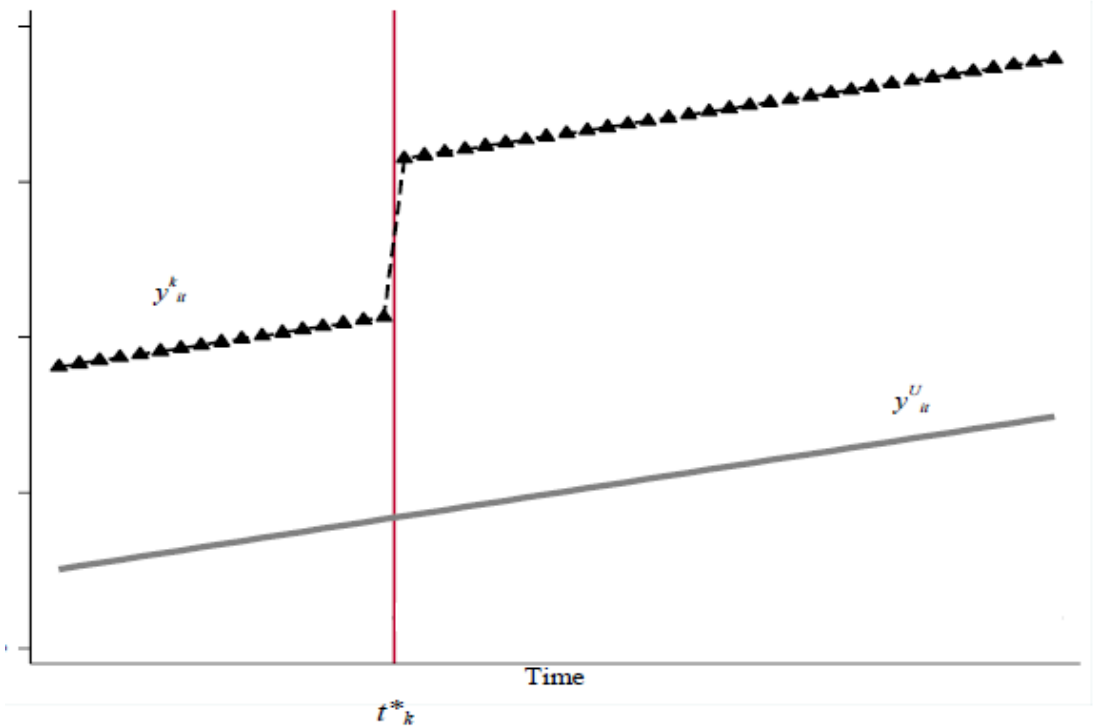


Figure: Difference in Difference structure

$\hat{\beta}^{DID} = (\bar{y}^{TREAT}_{POST} - \bar{y}^{TREAT}_{PRE}) - (\bar{y}^{CONTROL}_{POST} - \bar{y}^{CONTROL}_{PRE})$,

Add (year + cell) fixed effects to filter all other unobserved factors

Specificities of CMPs

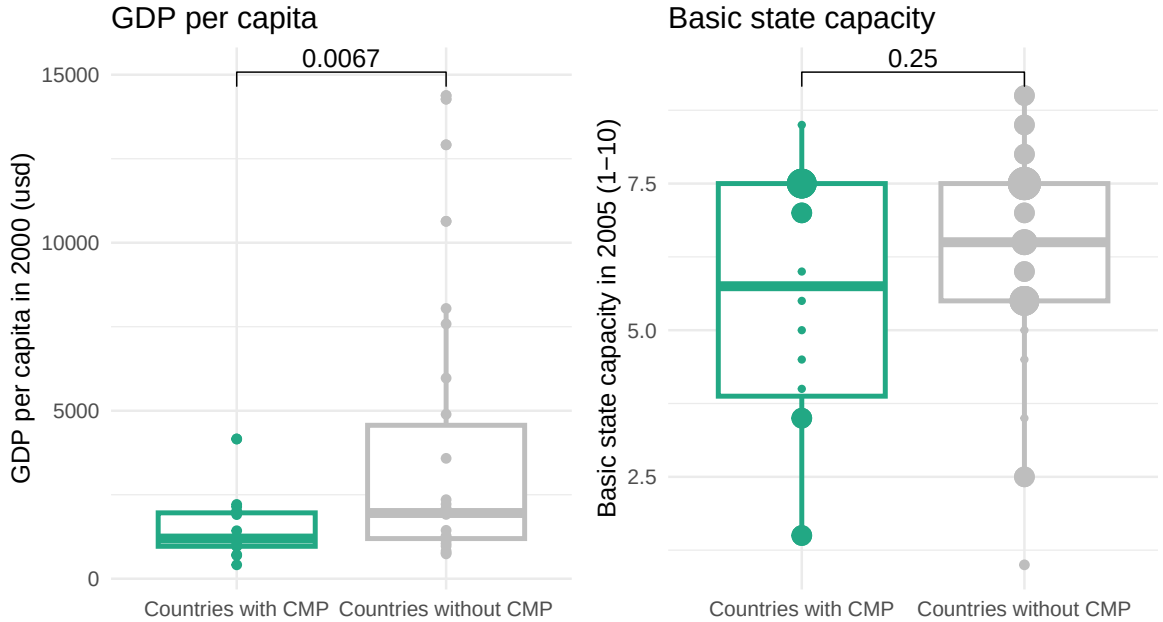


Figure: GDP per capita in 2000 (left) and basic state capacity score in 2005 (right) in SSA countries with and and without CMP. GDP per capita data come from the Maddison Project Database (Bolt et al., 2024). We took the GDP per capita for the year 2000, prior to the creation of all but one CMP (Kasanka NP in 1990). Basic state function score data come from the Bertelsmann Transformation Index project (2022). It quantifies the extent to which a state has the monopoly of force and provides basic public services (values ranges from 1 to 10, first observation in 2005). The size of each points is proportional to the number of countries having a given score (among countries with and countries without CMP).

Location bias of CMPs: matching

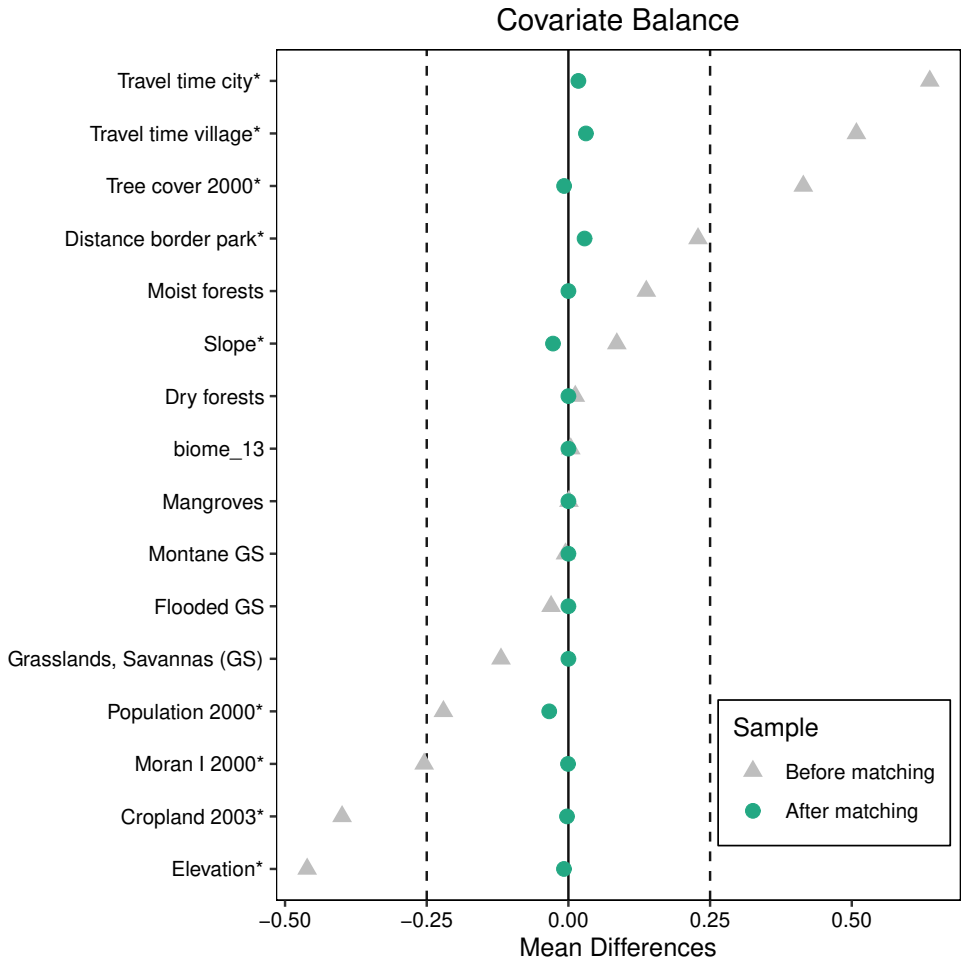
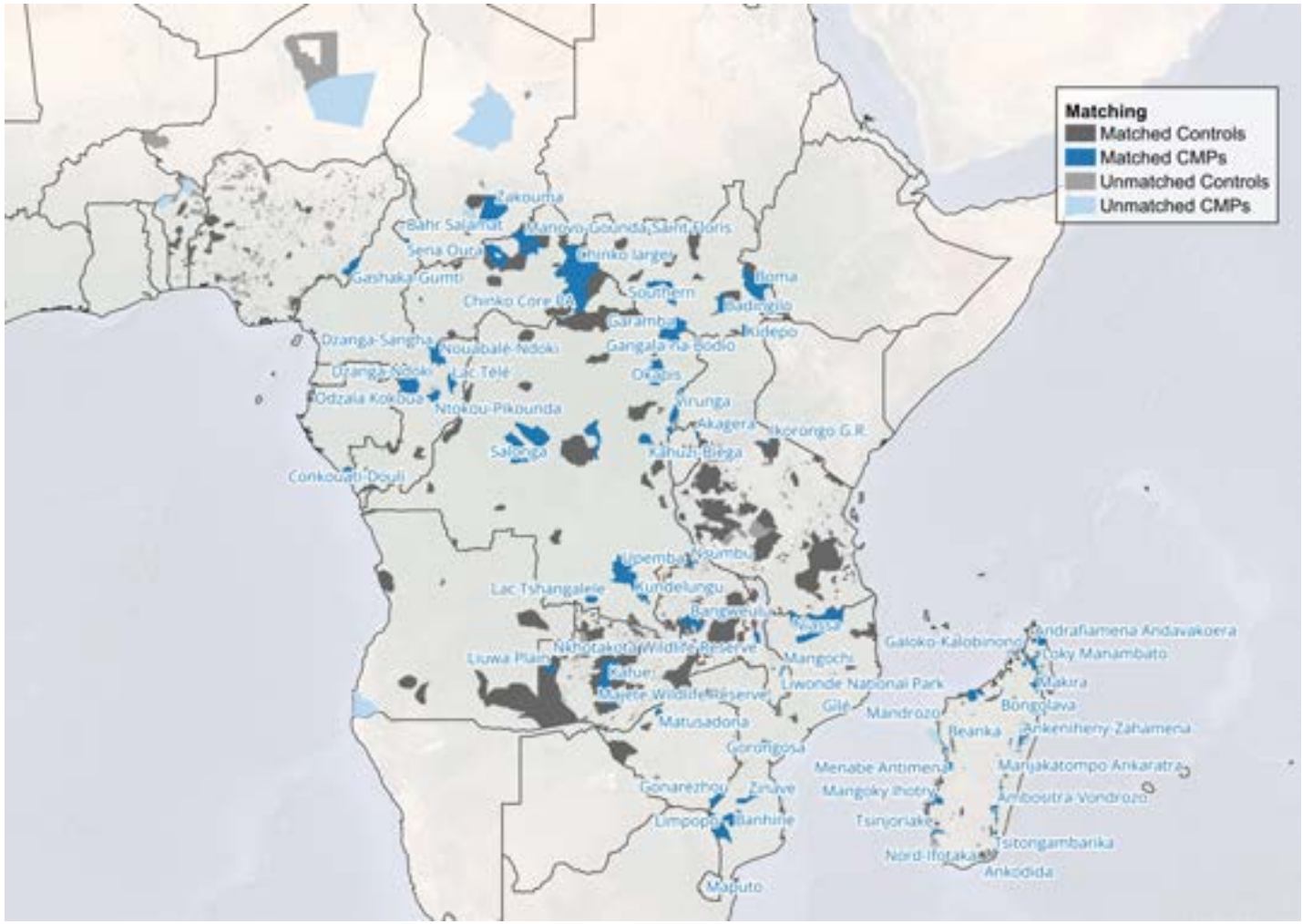


Figure: Differences in observable characteristics between PPP and other parks before (grey triangles) & after matching (green dots).

Matching procedure



Matching: parks kept (dark) and parks dropped (light). Matching conducted at the grid level (5km x 5km). The map was done with parks instead of grid cells for visibility. A park was considered as kept for this figure if at least one of its grid cell was matched.

- Matching: nearest-neighbor without replacement and using mahalanobis distance (caliper of 0.5)
- Matched on : initial forest cover, spatial pattern (Moran I), distance to PA border, population density, travel time to villages/cities, cropland, elevation, slope

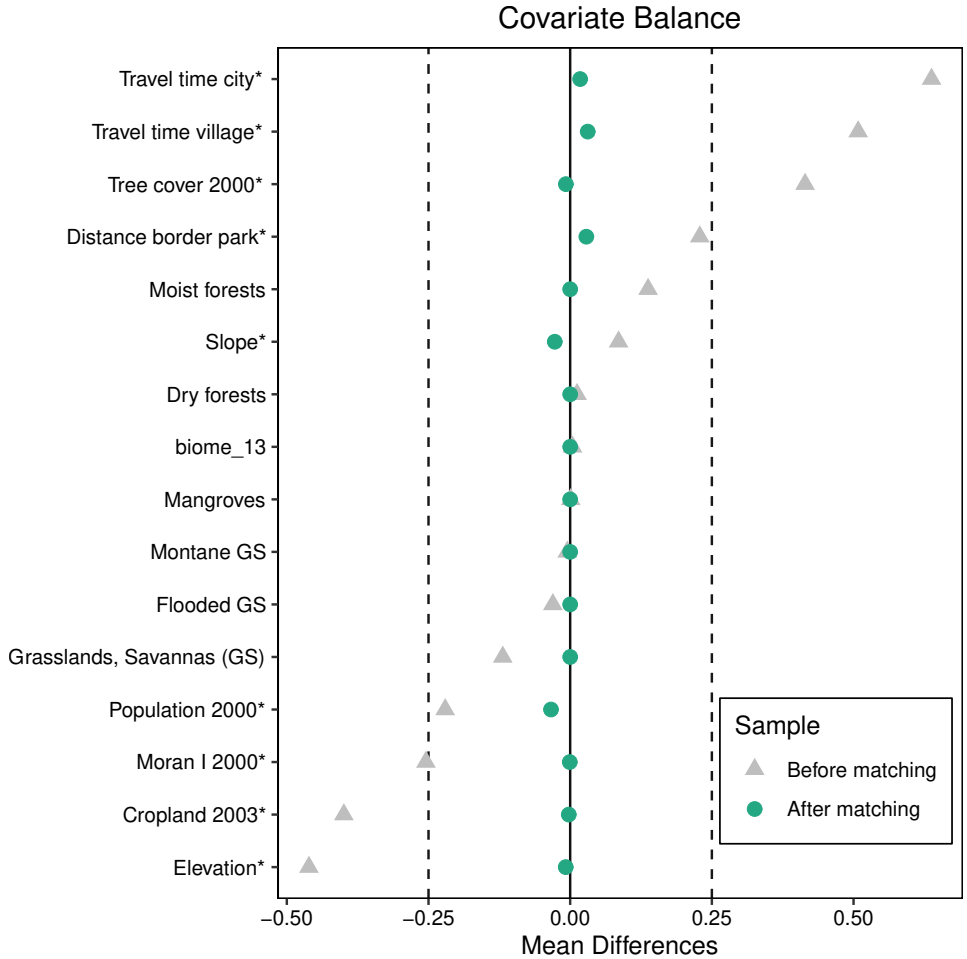
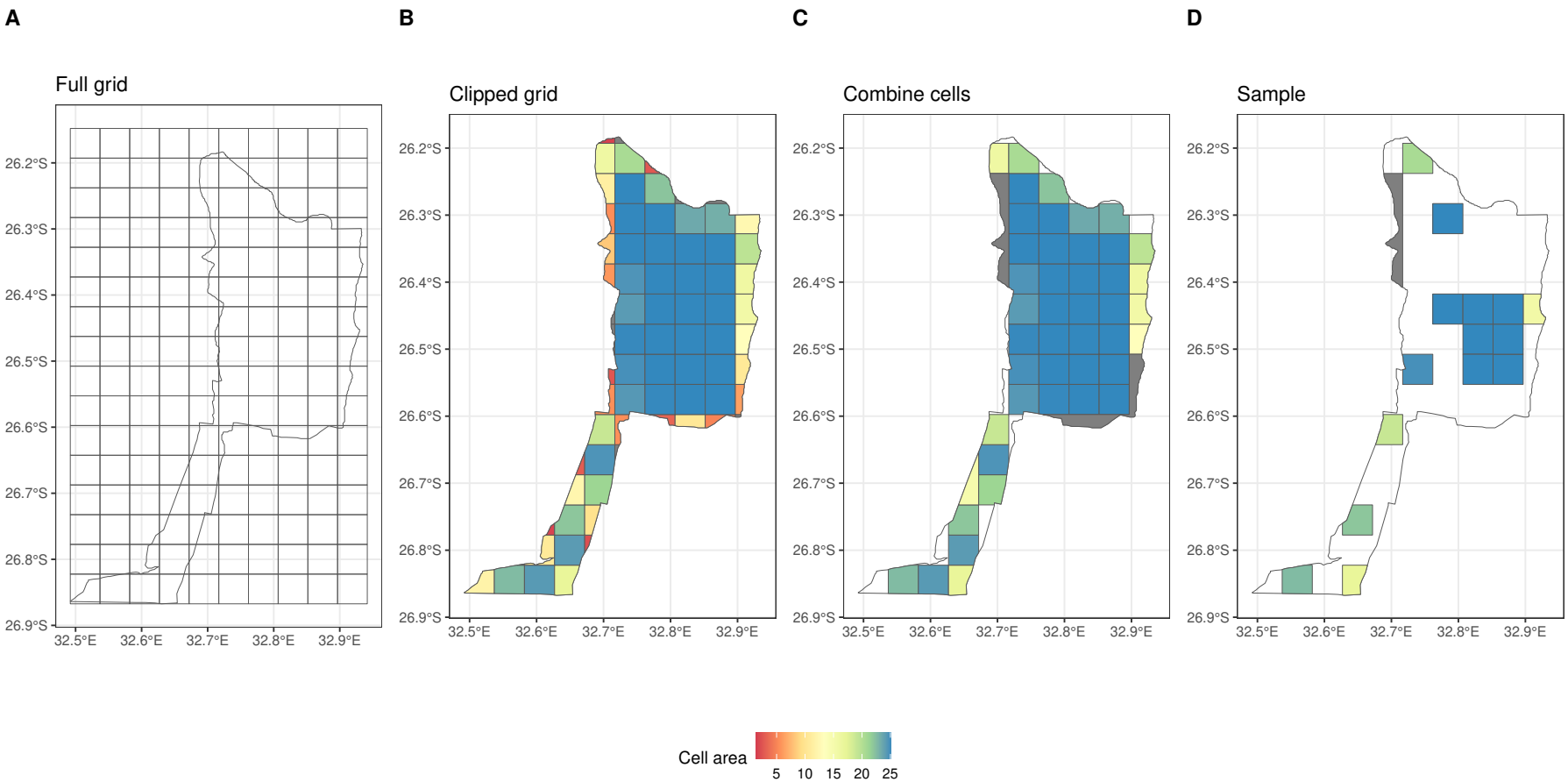


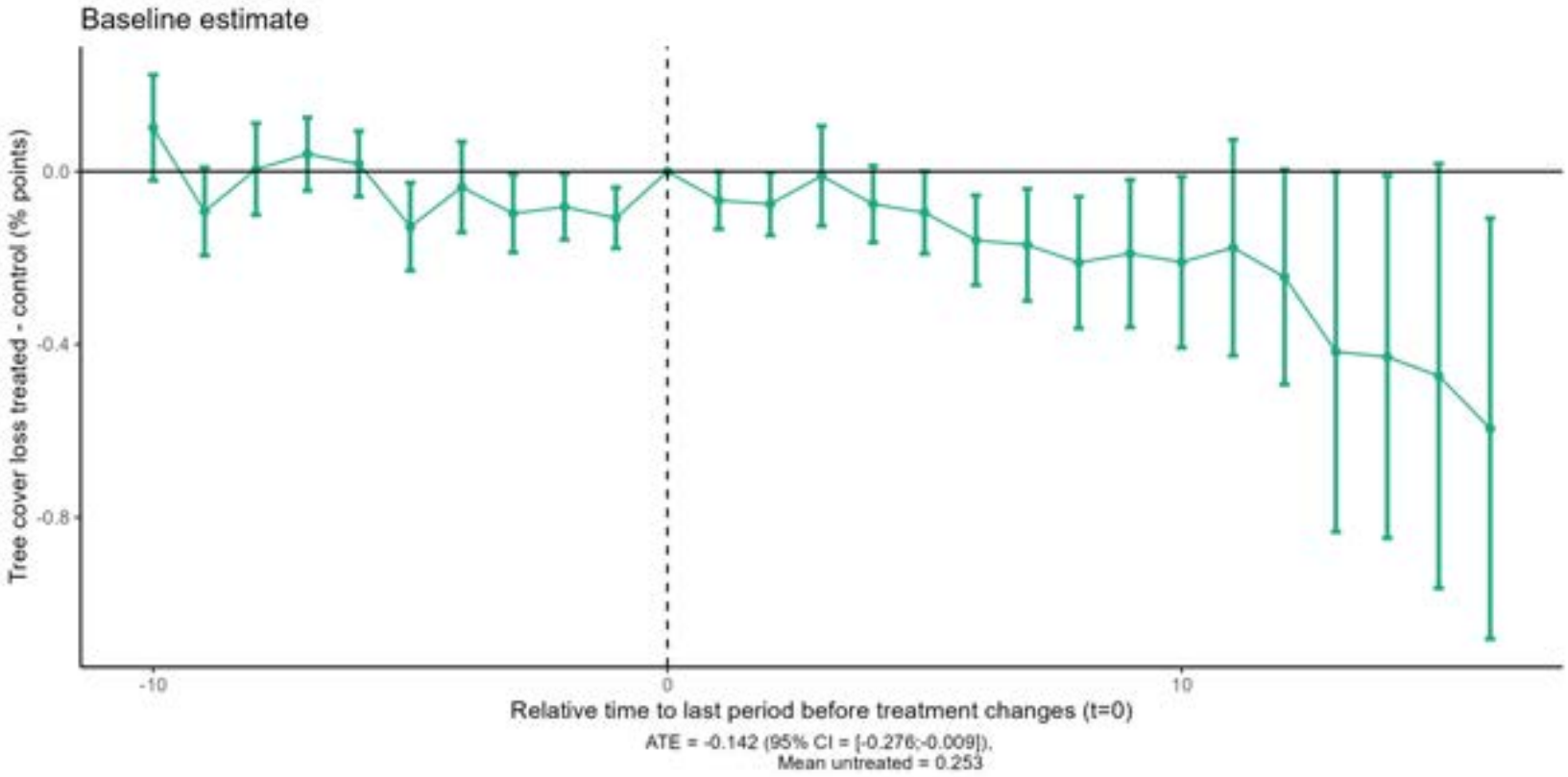
Figure: Differences in observable characteristics between PPP and other parks before (gray triangles) & after matching (green dots).

ILLUSTRATION OF THE GRID CONSTRUCTION



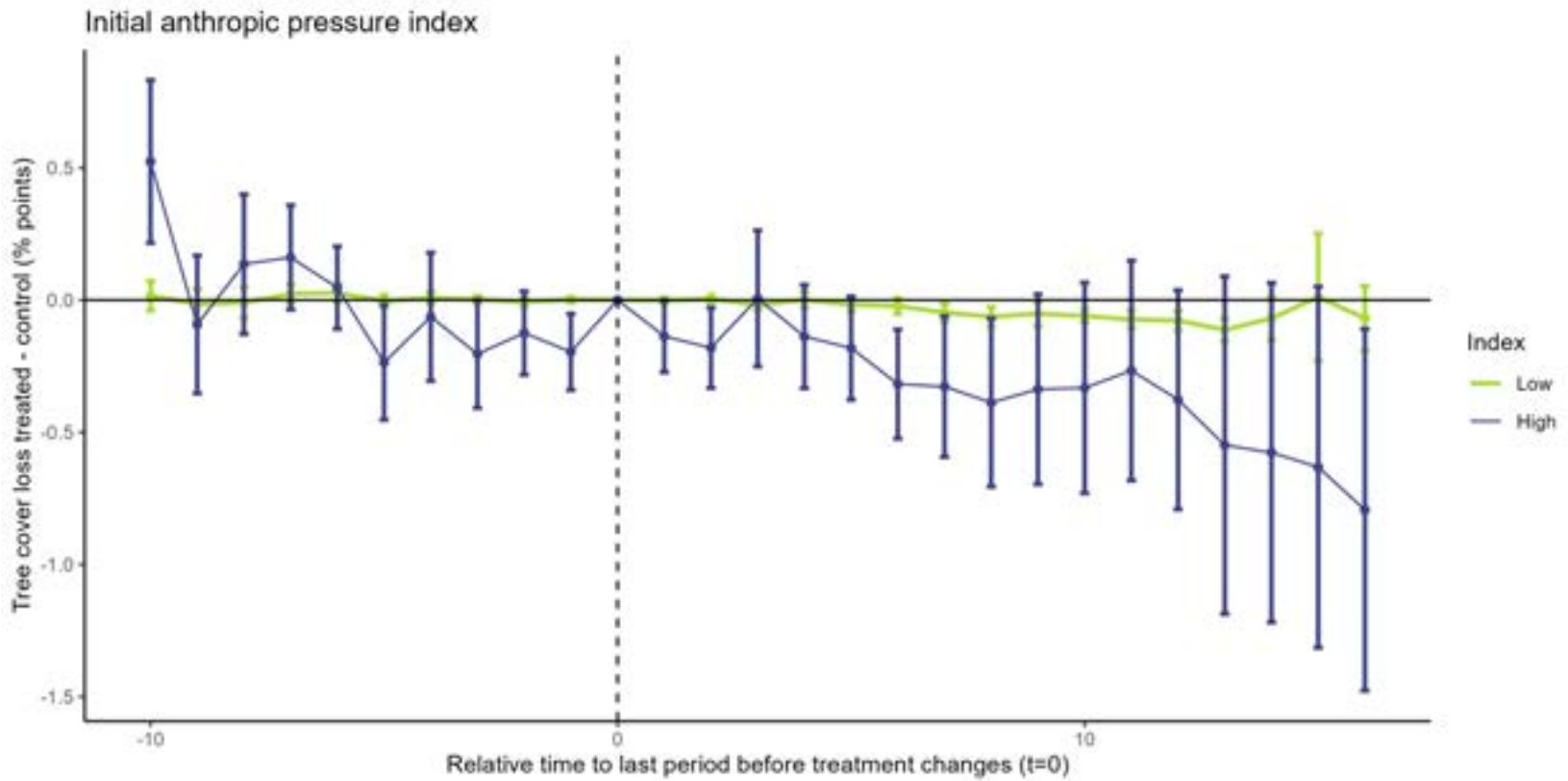
This figure illustrates the steps to create a grid for each park.

Relative efficiency of CMPs to limit deforestation



Additional impact of CMPs in terms of deforestation. Av. total effect: -14pp (+/- 13.4%). $\backsimeq$ 55% of average deforestation in controls. Less than 10% obs. treated $>$ 14 years.

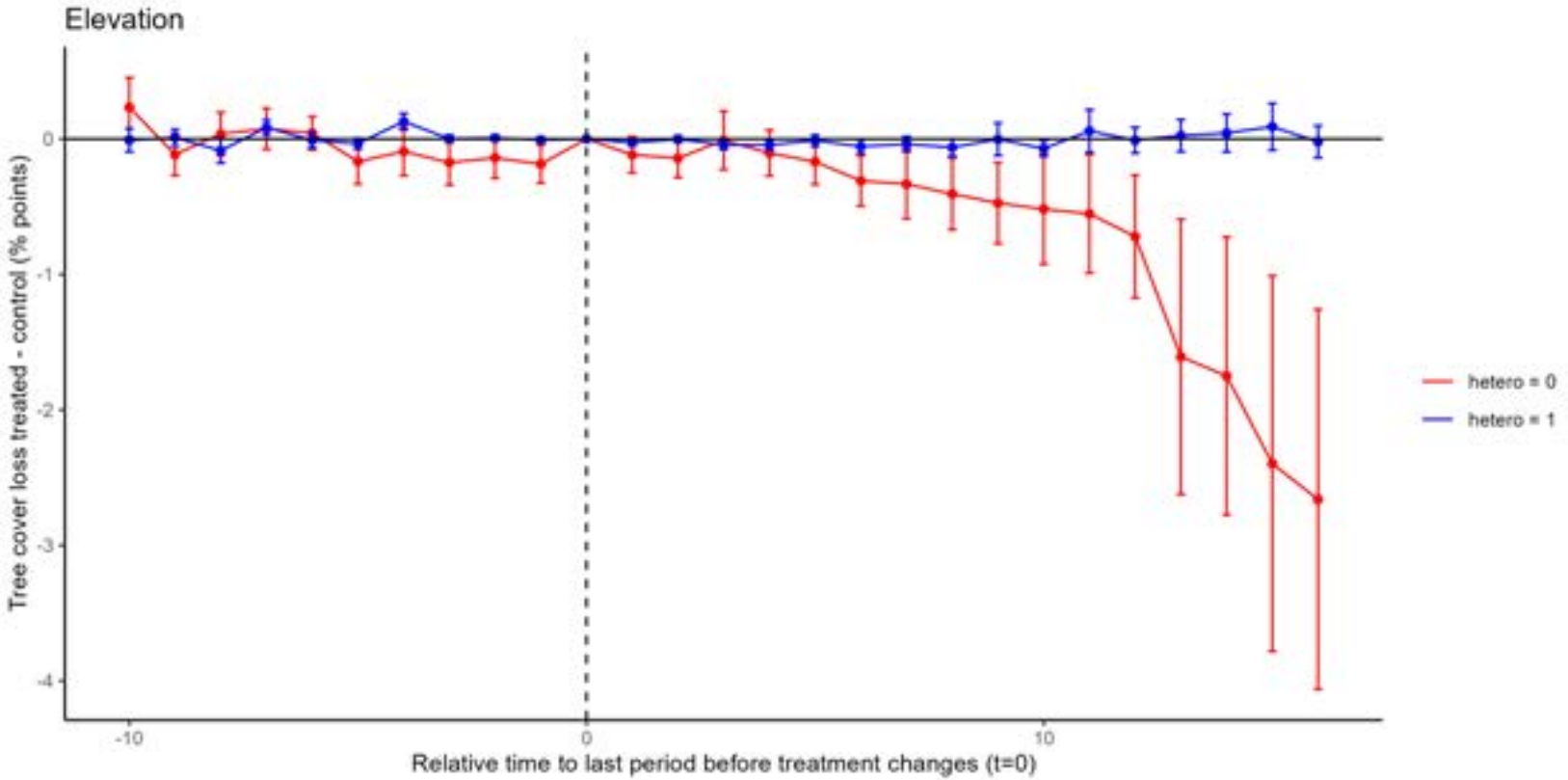
HETEROGENEITY



Additional impact, depending on the median value of an index of initial anthropic pressure[1].

[1] (Cover in 2000, cropland in 2003, population in 2000, travel-time to city/village in 2000, elevation, slope, distance to border)

HETEROGENEITY: ELEVATION



Additional impact, depending on the average value of an index of elevation.

POLICY IMPLICATIONS

- Large development of collaborative management, implying need for results → Prioritize developments in certain (highly threatened) contexts ?
- New models of conservation: revenue generating activities (Eco-tourism, Safari / game reserves, trophy hunting)...
- Ethical concerns: allegations of abuse against indigenous people (WWF, African Parks...)
- Privatisation / militarisation ? ⇒ inclusiveness / participation of local communities / IPL (local / community resource management & decentralization?)

Take aways

- CMPs may overcome a major drawback of conservation policies in poor countries (lack of capacity).
- PAs under CMPs manage to (additionally) reduce tree loss in cells/locations with higher initial anthropic pressure.
- The average total effect is about 14pp (+/- 13.4%), representing $> 55\%$ of average deforestation avoided.

Regression model

Use the date of entry into CMP and study changes in outcomes before / after compared to untreated observations

$$Def_{i,t} = \alpha_i + \gamma_t + \sum_{k=-10}^{-2} \beta_k \cdot CMP_{i,t}^k + \sum_{k=0}^{16} \beta_k \cdot CMP_{i,t}^k + \sum_c \tau_1 \cdot Country_c \times Year_t + \sum_b \tau_2 \cdot Biome_b \times Year_t + \epsilon_{i,t}$$

- $Def_{i,t}$ is deforestation rate, α_i is gridcell fixed effect, γ_t is year fixed effect
- $CMP_{i,t}^k$ indicates being k periods away from treatment
- Country-year ($\tau_1 \cdot Country_c \times Year_t$) and biome-year ($\tau_2 \cdot Biome_b \times Year_t$) trends included

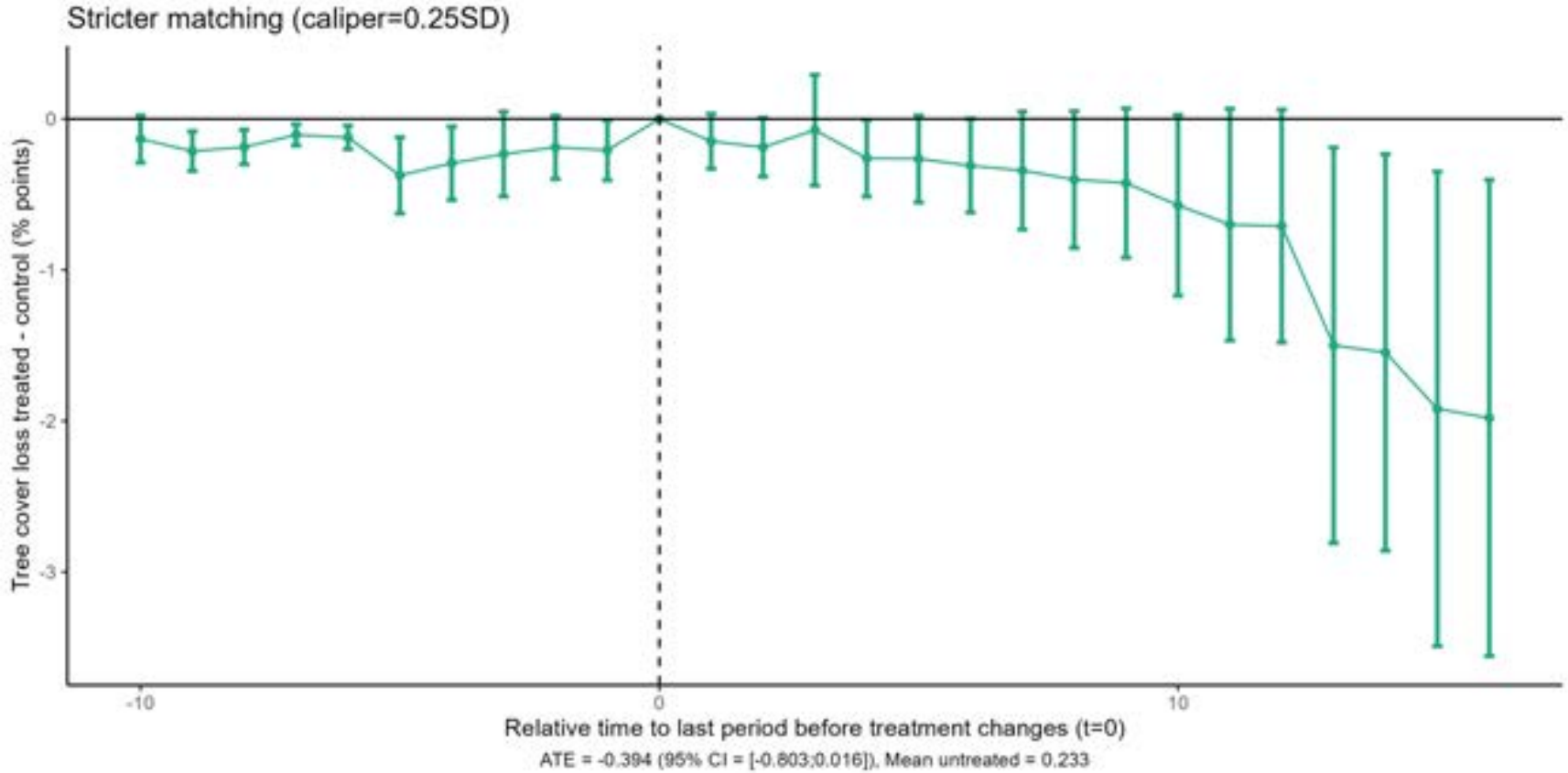
Regression model

$$Def_{i,t} = \alpha_i + \gamma_t + \sum_{k=-10}^{-2} \beta_k \cdot CMP^k_{i,t} + \sum_{k=0}^{16} \beta_k \cdot CMP^k_{i,t} + \sum_c \tau_1 \cdot Country_c \times Year_t + \sum_b \tau_2 \cdot Biome_b \times Year_t + \epsilon_{i,t}$$

Estimation:

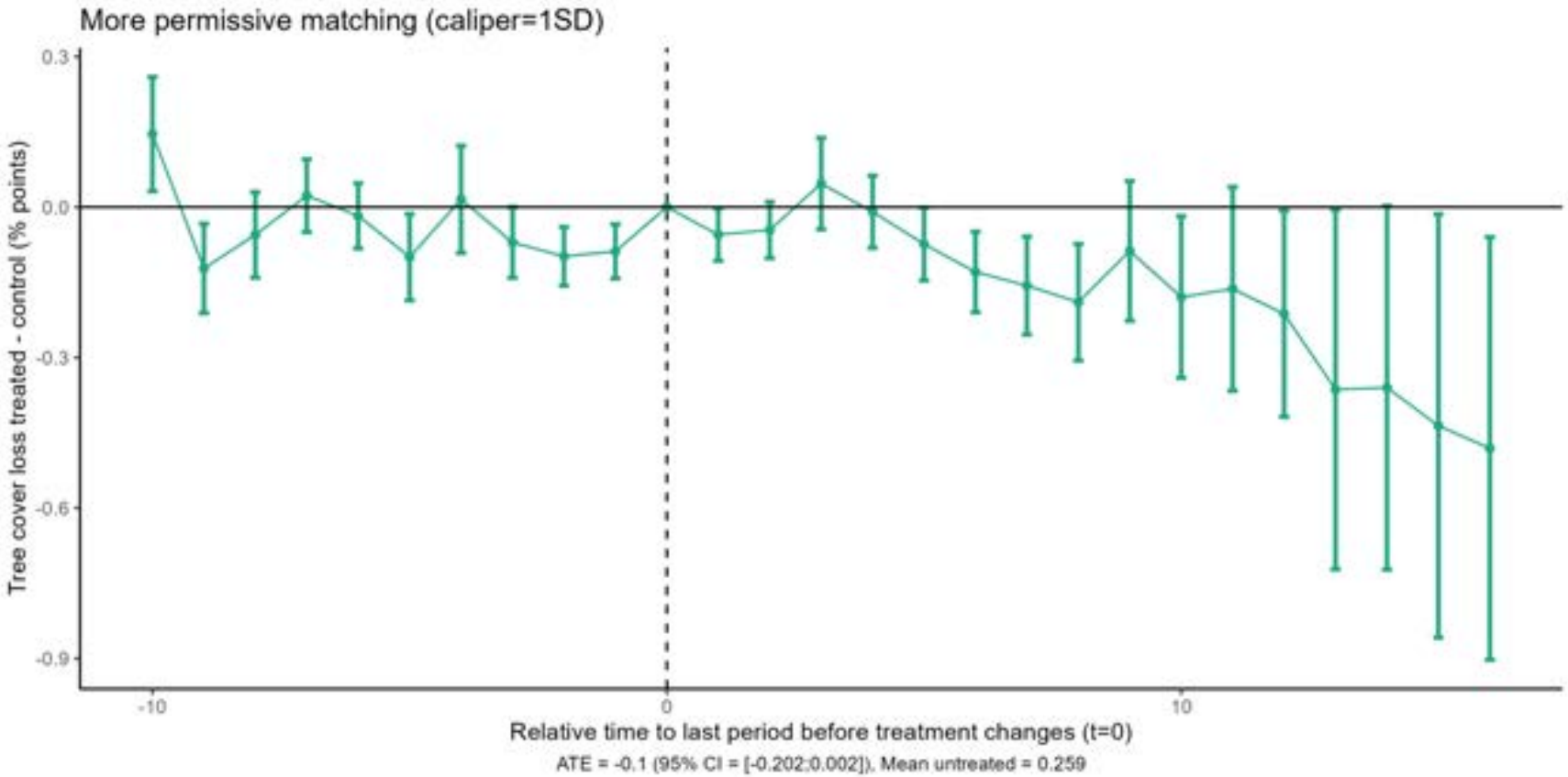
- Advantage: park which are not yet treated can be used as control for already treated obs
- Problem: Classic OLS was proven to provide biased $\hat{\beta}_k$ when staggered treatment (De Chaisemartin and D'Haultfoeuille 2020, Goodman-Beacon, etc): negative weights and compute "forbidden differences"
- Estimate with De Chaisemartin and D'Haultfoeuille 2024

ROBUSTNESS OF THE RESULTS: STRICTER MATCHING



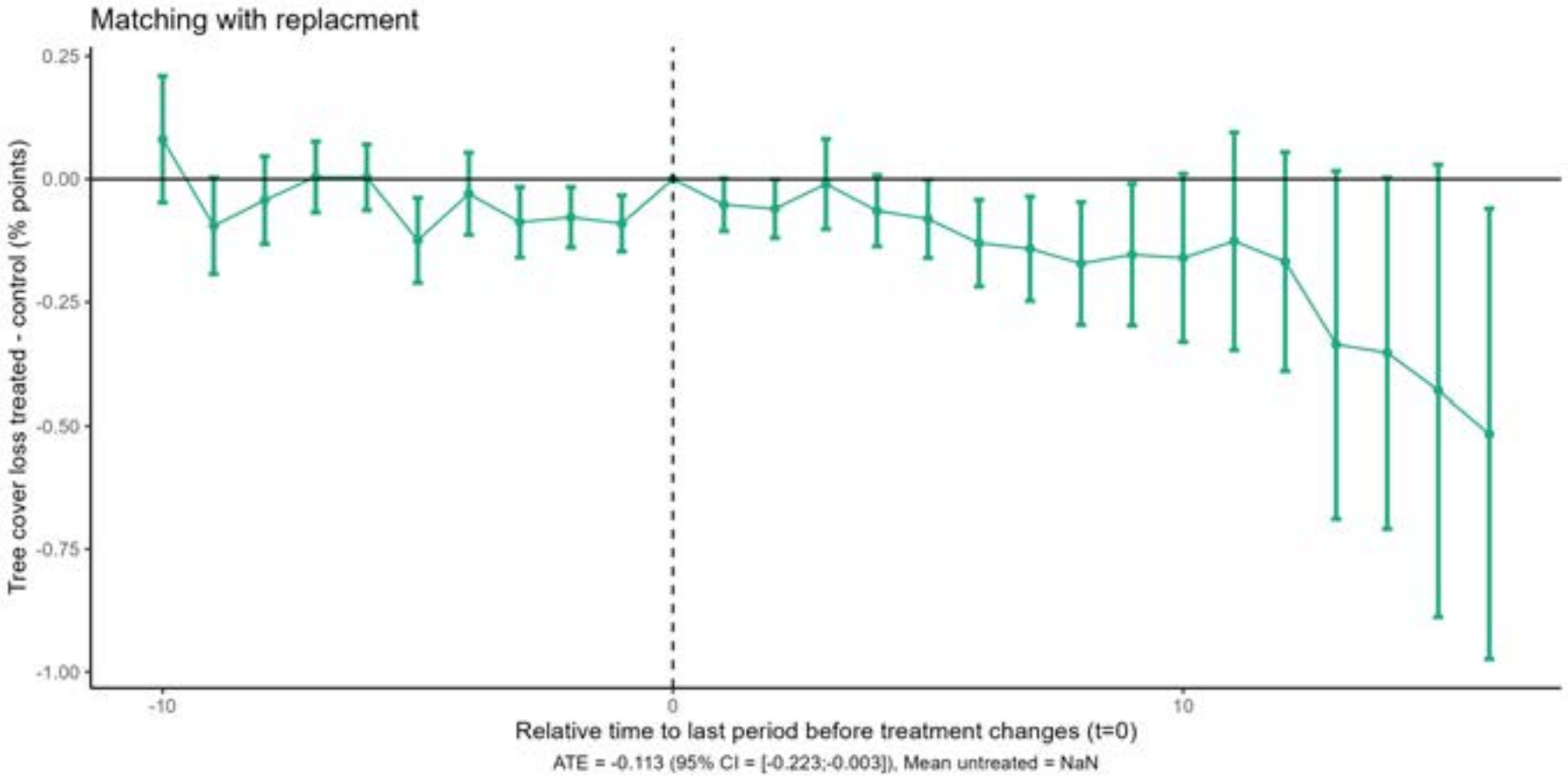
Stricter matching, caliper=.25 sd, benchmark: nearest-neighbor matching without replacement and using a mahalanobis distance in matchit (63). We set a caliper of 0.5, standard deviation to keep acceptable pairs.

ROBUSTNESS OF THE RESULTS: MORE PERMISSIVE MATCHING



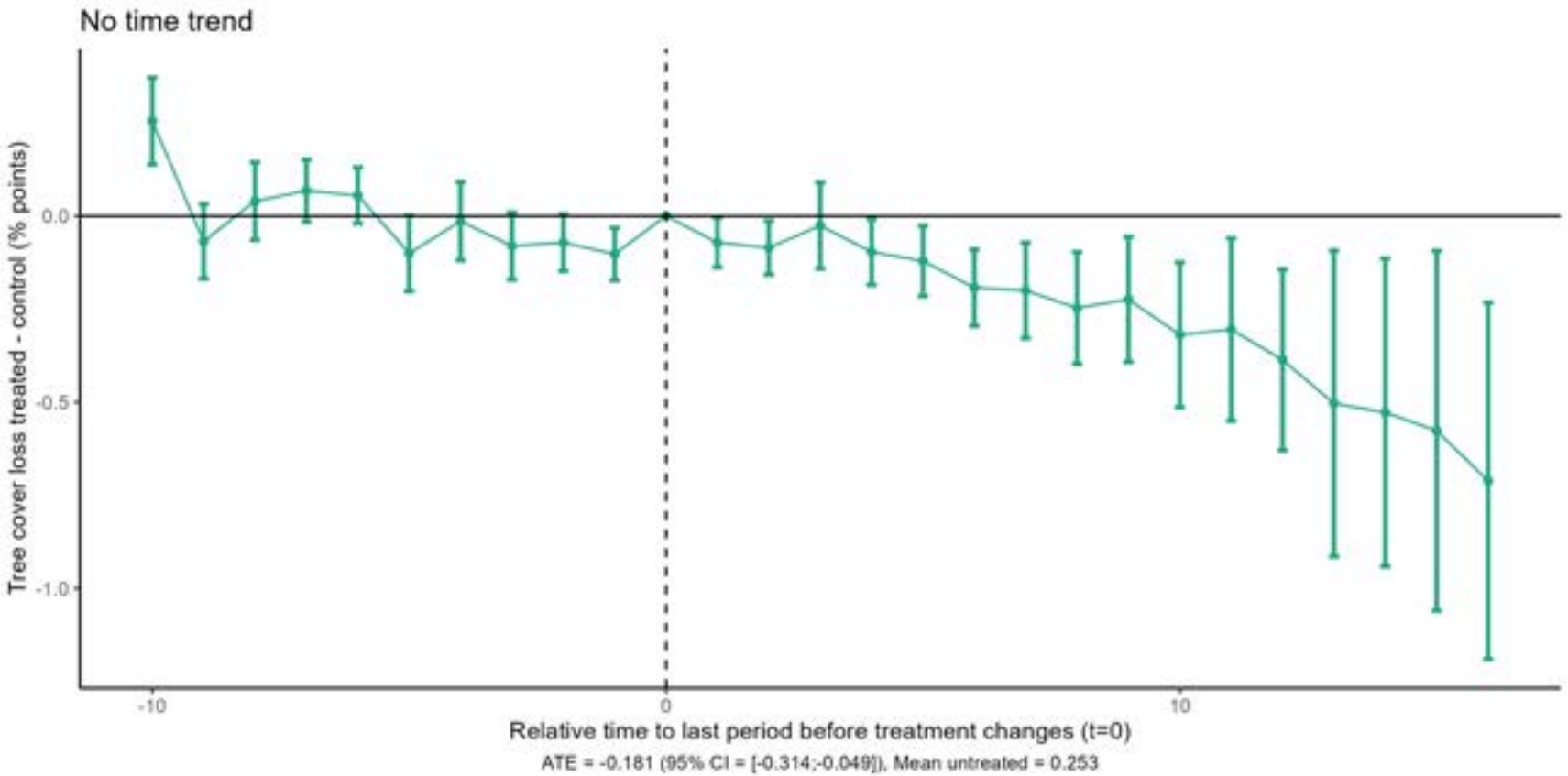
Permissive matching, caliper=.1 sd

ROBUSTNESS OF THE RESULTS: MATCHING WITH REPLACEMENT



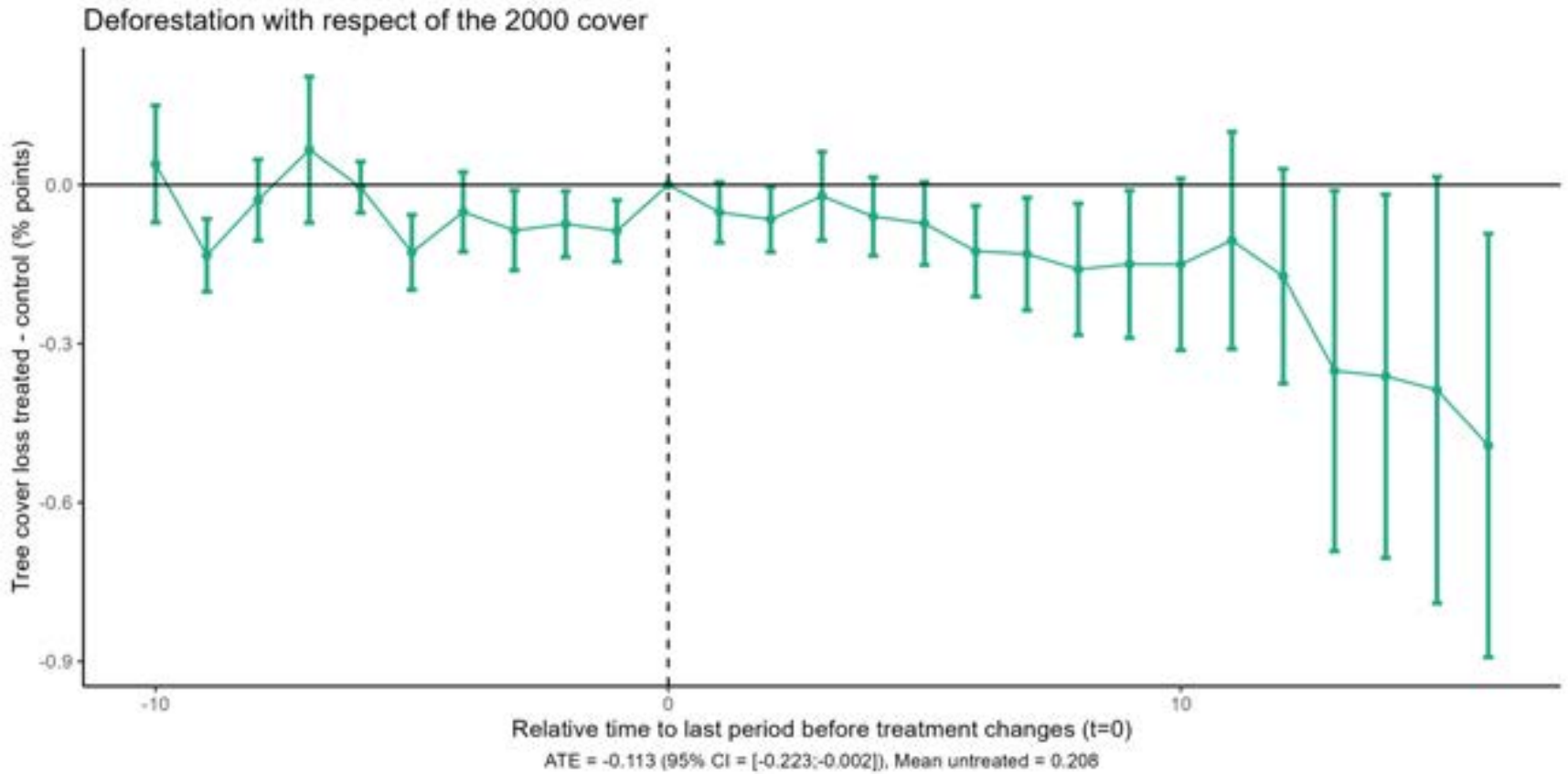
Matching with replacement

ROBUSTNESS OF THE RESULTS: NO TIME TREND



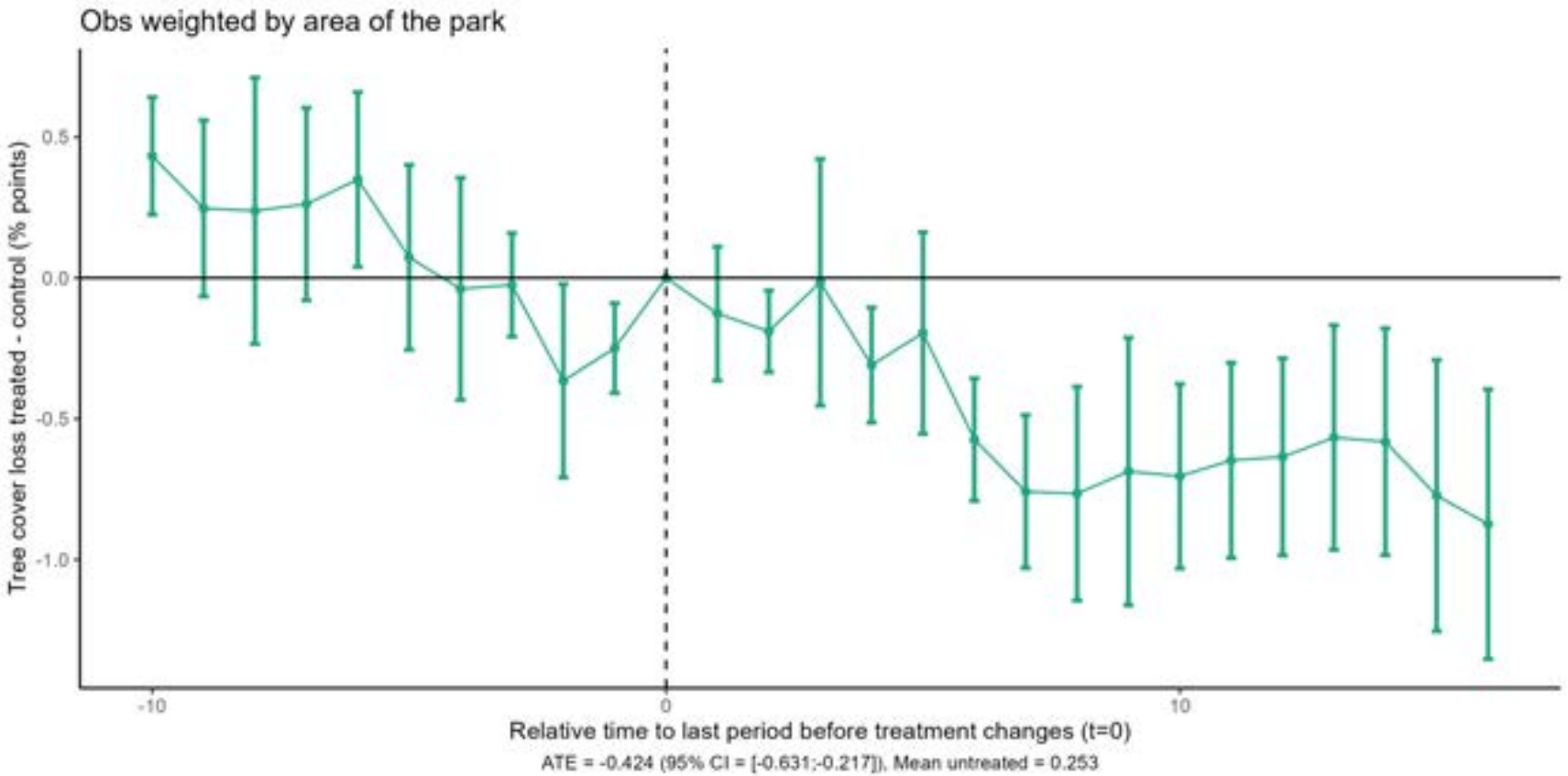
DID without biome- and country-year trends

ROBUSTNESS OF THE RESULTS: DEF. DEFOR. AS SHARE OF 2000 COVER



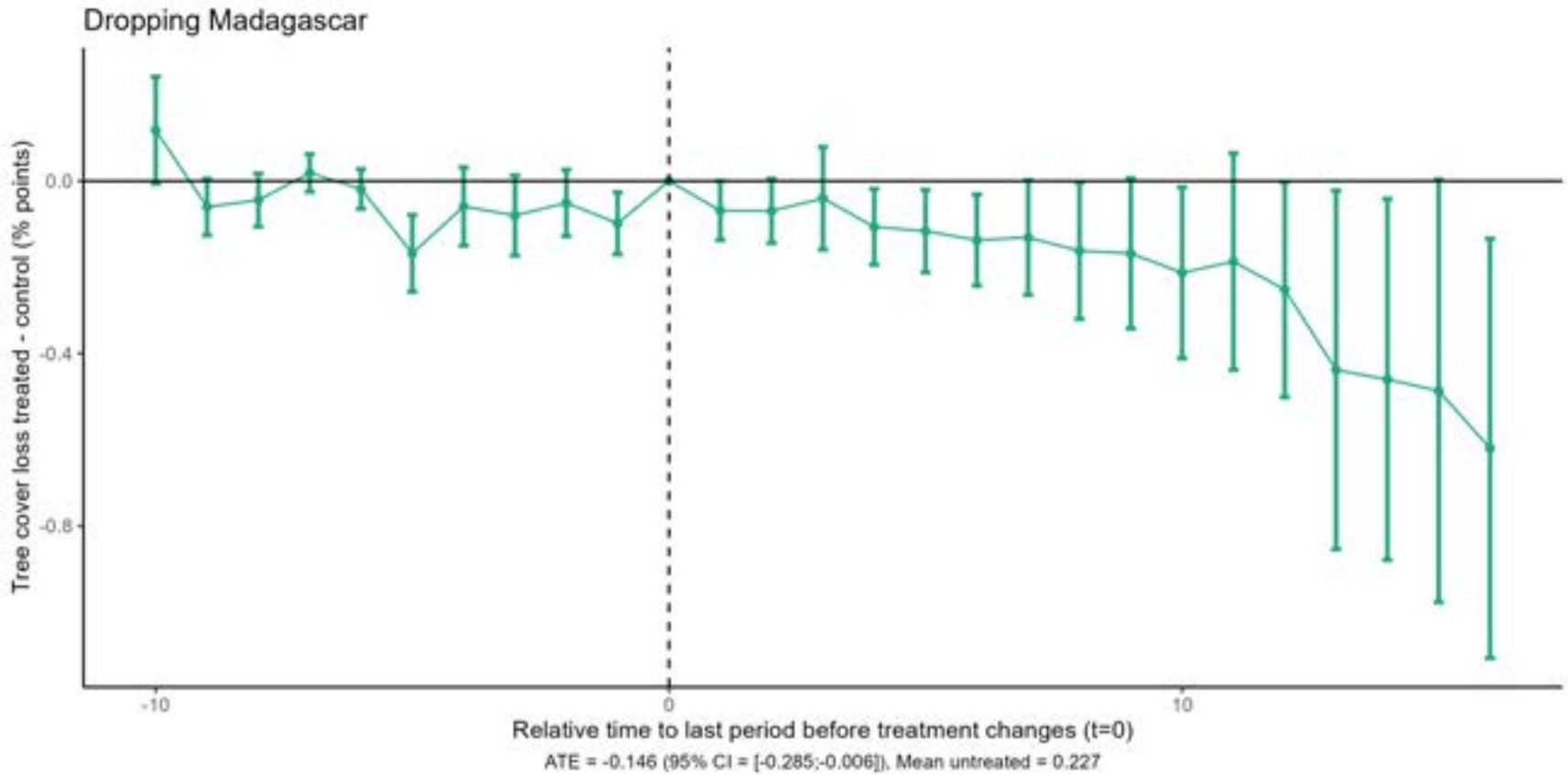
Deforestation rate with respect to the year 2000

ROBUSTNESS OF THE RESULTS: PARK SIZE WEIGHTING



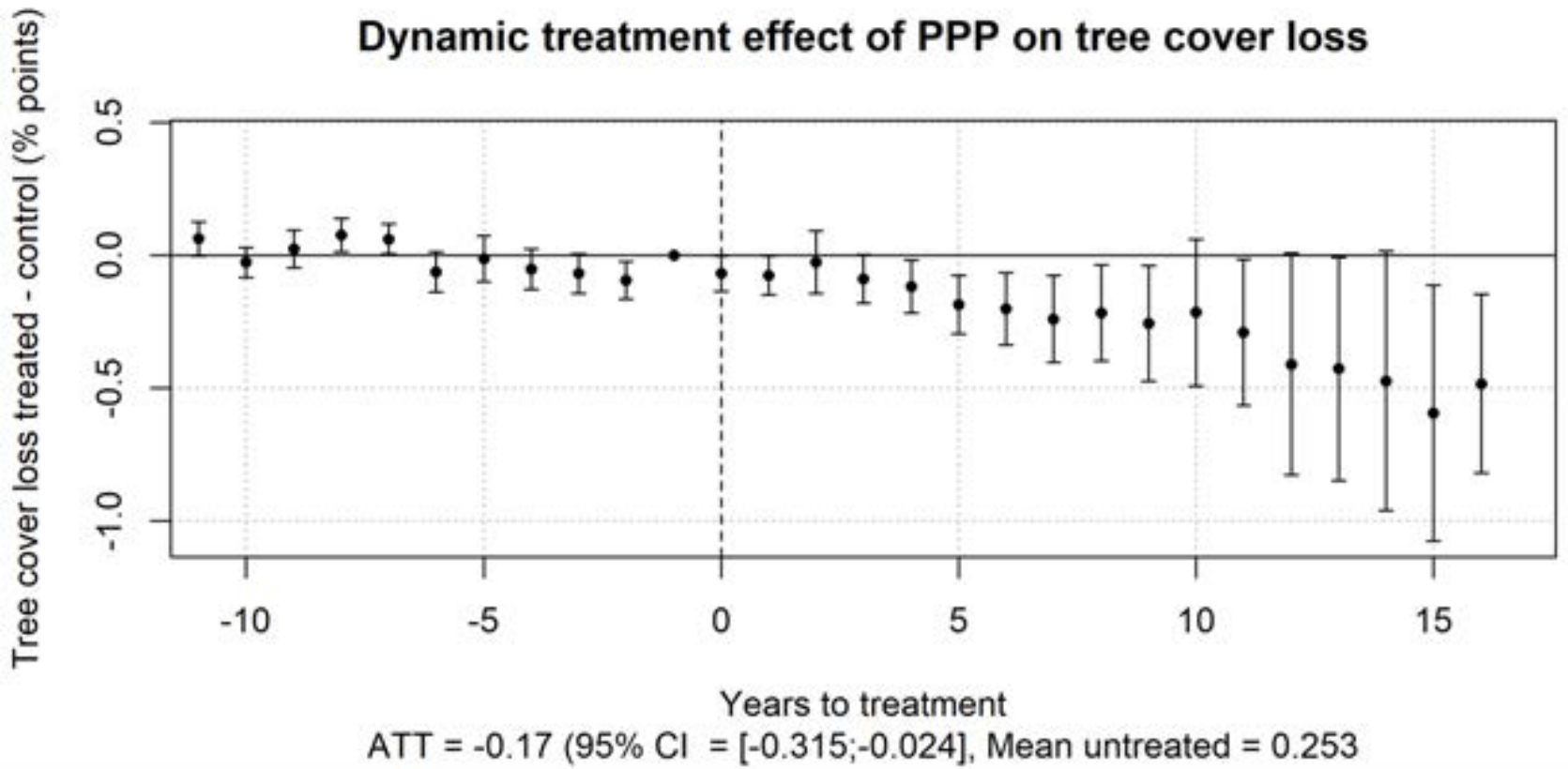
Weighted by the inverse of the area of a park

Robustness of the results: dropping Madagascar



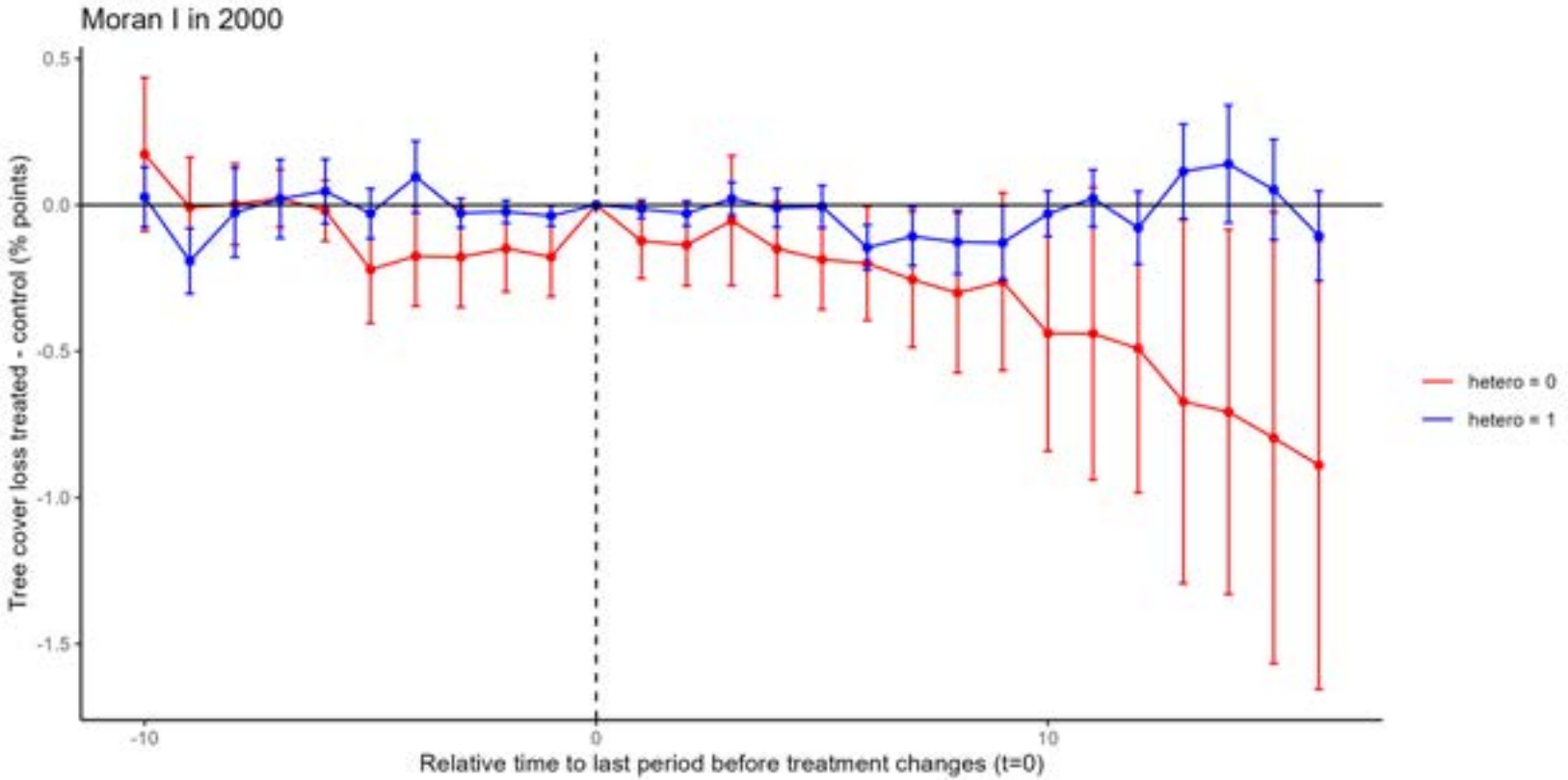
Dropping Madagascar

ROBUSTNESS OF THE RESULTS: ALTERNATIVE ESTIMATOR



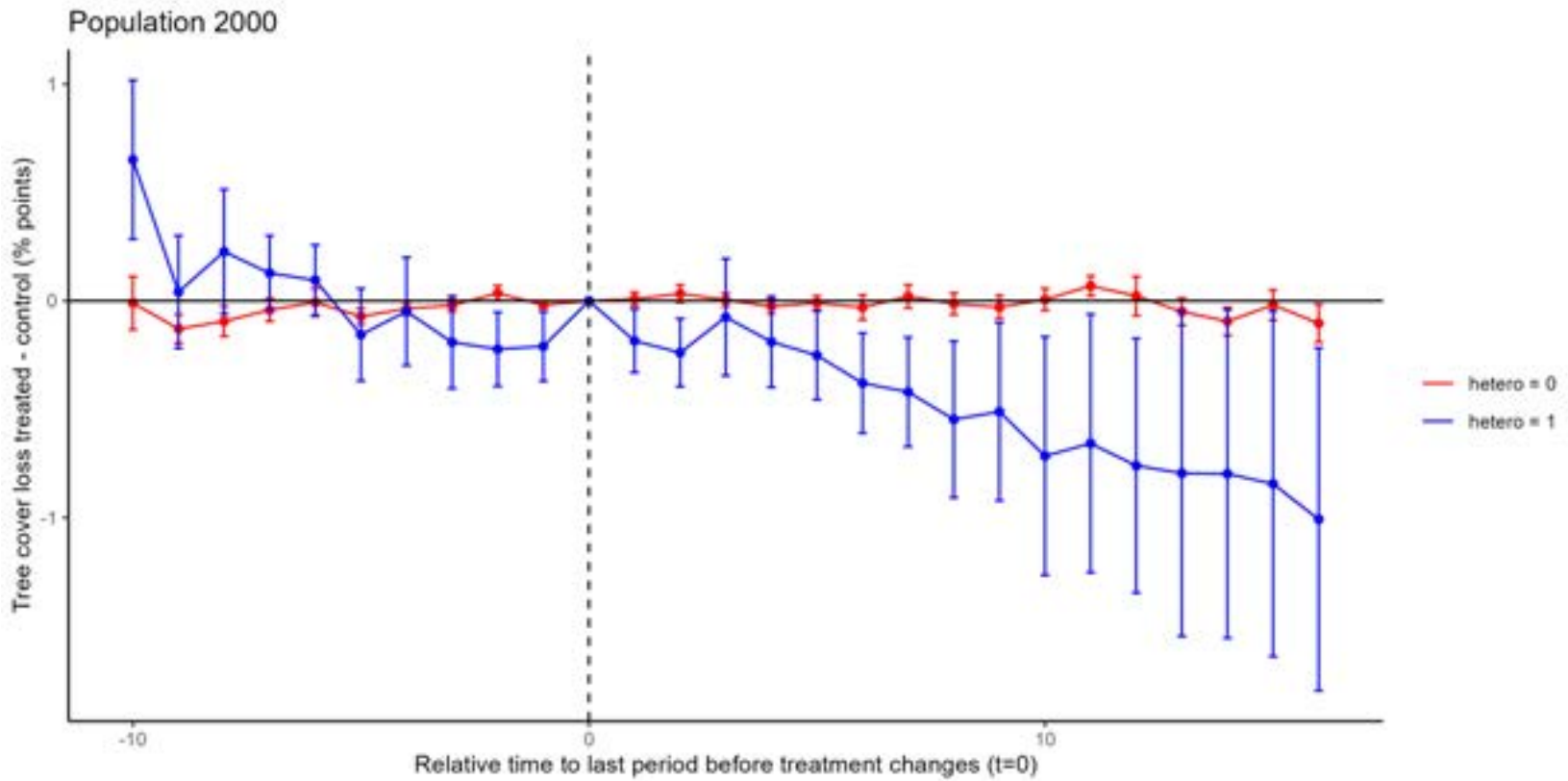
Alternative estimator from Sun and Abraham

HETEROGENEITY: FOREST FRAGMENTATION



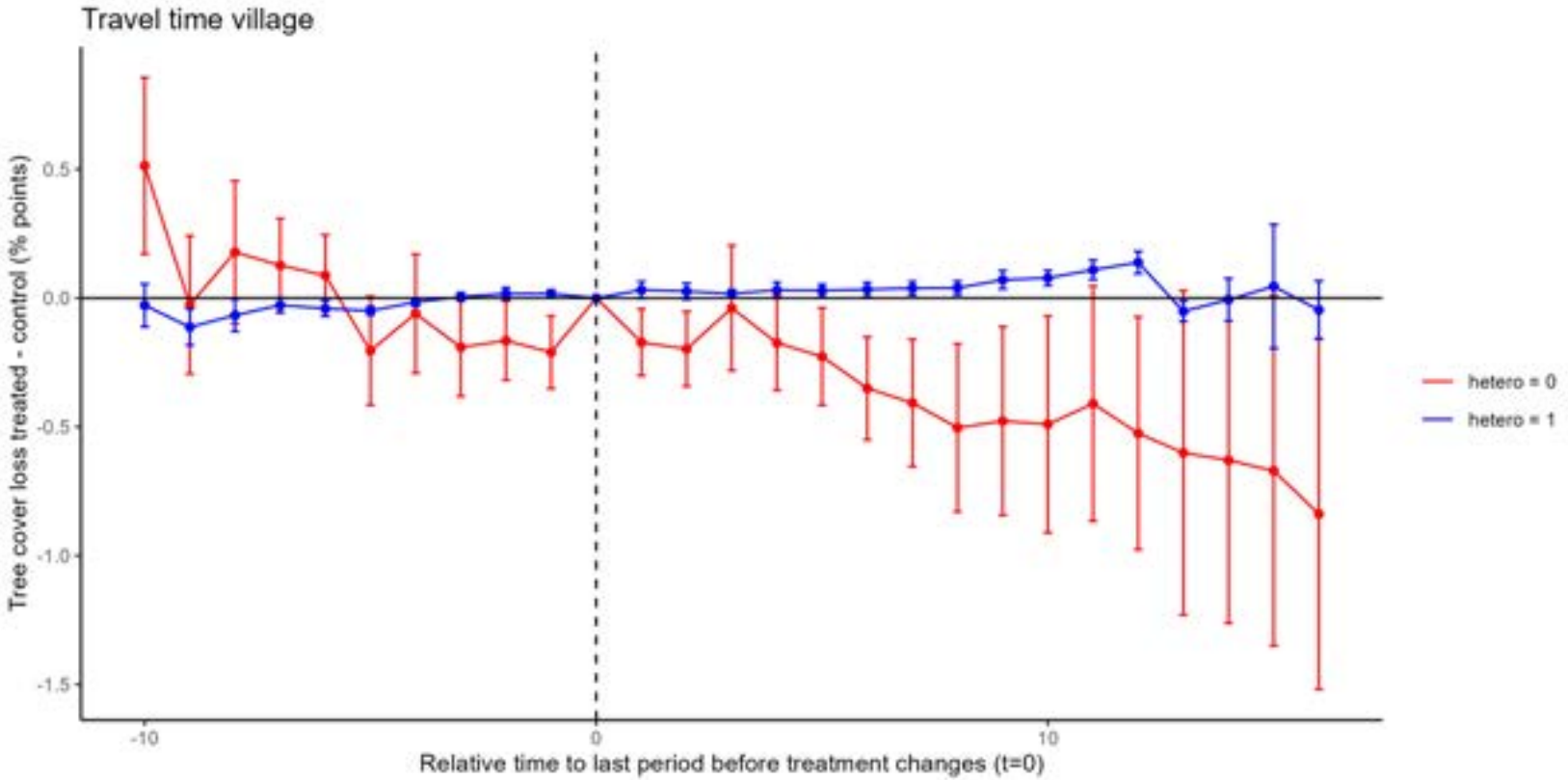
Additional impact, depending on the median value of an index of fragmentation (Moran's I).

Heterogeneity: Population



Additional impact, depending on the median value of an index ofpopulation.

HETEROGENEITY: TRAVEL TIME TO NEAREST VILLAGE



Additional impact, depending on the median value of time distance to the nearest village in 2000.