Patrols Deter Poachers: Causal Inference with Bayesian Modeling and Field Tests as a Shock

Rachel Guo[1], Lily Xu[1], Andrew Perrault[2]

[1]Harvard University, [2]The Ohio State University

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Guo Xu Perrault

A Causal Study of Deterrence

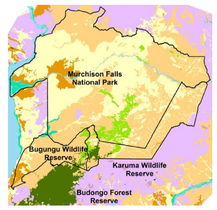
Answering a long-standing question in conservation:

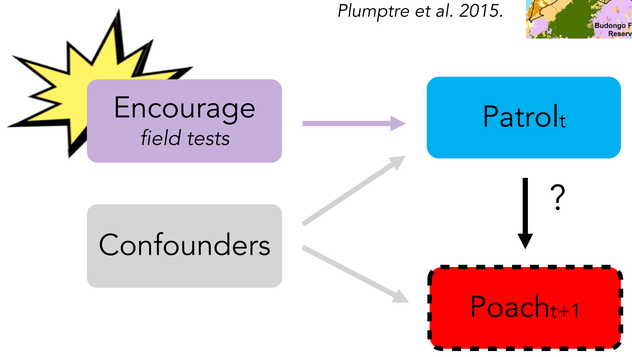
Are poachers deterred by ranger patrols?

Ranger removing a snare. Photo: *Wildlife Conservation Network.*

Hippos in Murchison Falls National Park. Photo: *Wikimedia Commons.*

Murchison Falls National Park in Uganda. Photo: *Plumptre et al. 2015.*



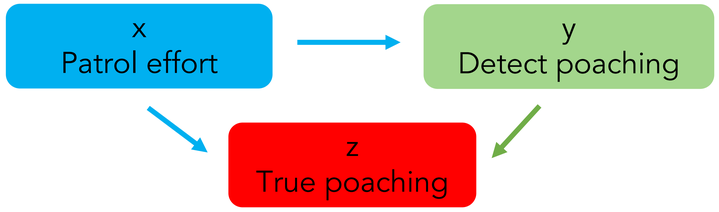


Key Challenge 2

Imperfect detection of snares → Impute true presence of snare

Bayesian model for imperfect detection:

Modeling true presence of illegal activity



Goal: learn *z*, which is not observed, using *y* and *x* using *neural network predictions and domain insight*

$$p(z \mid y, x, f) = \begin{cases} \dfrac{p(z \mid f)p(\neg y \mid x, z, f)}{p(\neg z \mid f) + p(z \mid f)p(\neg y \mid x, z, f)} & \text{if } y = 0 \\ 1 & \text{if } y = 1 \end{cases}$$

domain insight → $p(z \mid f) = \lim_{x \to \infty} p(y \mid x, f)$

geospatial features (static and dynamic)

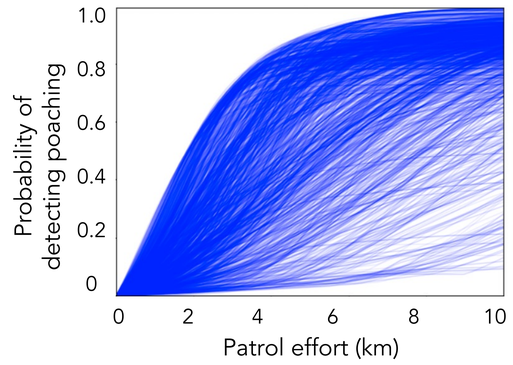
$$p(\neg y \mid x, z, f) = 1 - p(y \mid x, z, f)$$

NN model output

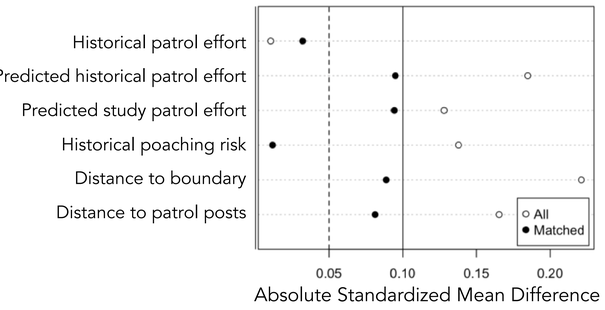
$$= 1 - \frac{p(y \mid x, f)}{p(z \mid f)}$$

Neural network learning

More patrol effort leads to higher probability of detecting poaching

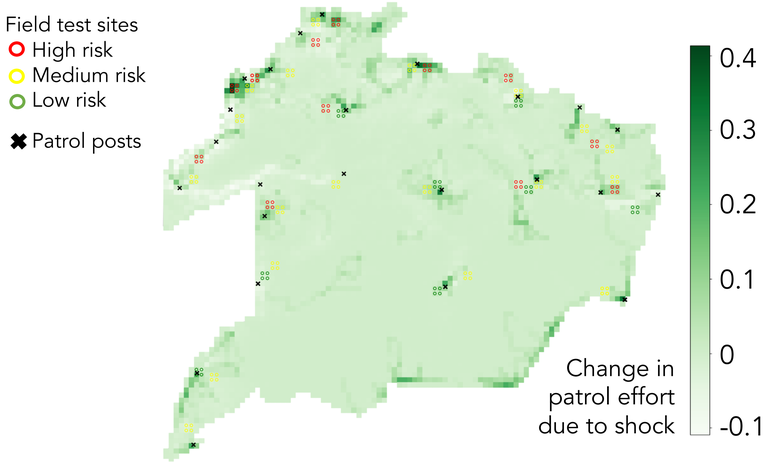


Covariates balanced in matches



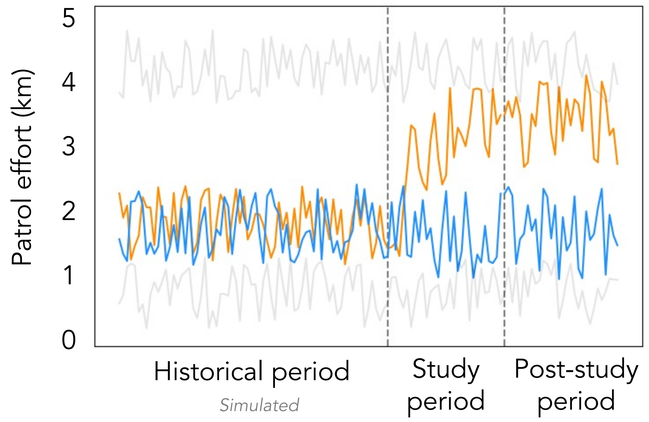
Key Challenge 1

RCTs not feasible → Historical field tests as shock to system affecting patrols



Key Challenge 3

Confounding in observational data → Match sites with similar historical patrolling and different study-period patrolling



Weighted logistic regression

Regress imputed post-study poaching outcomes on change in patrol induced by shock using weights from matching

Causal Effect	Robust Std. Err.	95% conf. interval
-0.313	0.135	[-0.578, -0.047]

Deterrence!

An additional unit of patrolling from expectation causes an average reduction in the log odds of poaching probability by 0.313. *First causal result.*