Treaties, Transfers and Trees:

Can international cooperation accomplish conservation?

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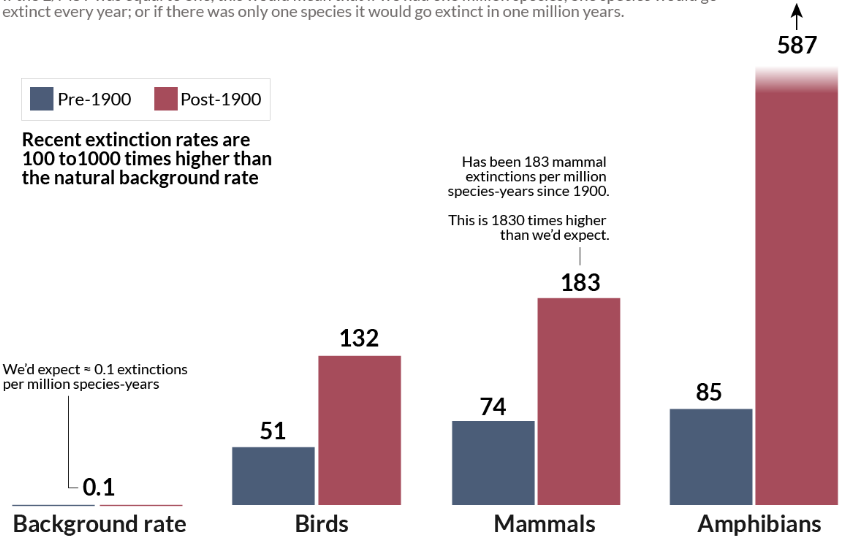
December 10, 2021

Are species going extinct faster than we'd expect?

Species extinction rates are measured in extinctions per million species-years (E/MSY).
If the E/MSY was equal to one, this would mean that if we had one million species, one species would go extinct every year; or if there was only one species it would go extinct in one million years.



Note: Species defined as 'probably exinct' by the IUCN are included as species extinctions.
Data Source: Pimm et al. (2014). The biodiversity of species and their rates of extinction, distribution, and protection. *Science*.
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Motivation

- In 2010, the United Nations Convention on Biological Diversity set 20 targets — the Aichi Biodiversity Targets — to be achieved by 2020

Target 4
By 2020, at the latest, Governments, business and stakeholders at all levels have taken steps to achieve or have implemented plans for sustainable production and consumption and have kept the impacts of use of natural resources well within safe ecological limits.

Target 5
By 2020, the rate of loss of all natural habitats, including forests, is at least halved and where feasible brought close to zero, and degradation and fragmentation is significantly reduced.

Target 17
By 2015 each Party has developed, adopted as a policy instrument, and has commenced implementing an effective, participatory and updated national biodiversity strategy and action plan.

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- The world missed all of them!

Research questions

- Can an international agreement significantly increase global conservation?
- What is the role of transfers and investments in achieving this goal?
- How do dynamic incentives affect outcomes such as participation and conservation?

Overview of the “paper”

- I develop a dynamic model where countries choose depletion and clean investment rates
  - → Depletion is a public bad (habitat/biodiversity loss), but increases productive agricultural land for the home country
  - → Clean technology provides alternative income source

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- I derive benchmark outcomes: BAU (non-cooperative) and first-best
- I study a coalition formation game
  - → Countries choose participation, duration of the agreement, conservation, investments and transfers

Relation to the existing literature

- International Environmental Agreements
  - → Biodiversity: Barrett (1994b) and Barrett (2021); Eichner and Pethig (2013); Winands, Holm-Müller, and Weikard (2013); Alvarado-Quesada and Weikard (2017)
  - → Dynamics: Barrett (1994a); Rubio and Ulph (2007); Battaglini and Harstad (2016)
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  - → Cost-effectiveness: Engel, Pagiola, and Wunder (2008); Gibbons et al. (2011)
- Optimal depletion of exhaustible resources
  - → Hotelling (1931); Dasgupta and Heal (1974) and Dasgupta, Eastwood, and Heal (1978)

Roadmap

Introduction

Model

Coalition Formation Game

Conclusions

Model

Income and consumption

- My model builds on Battaglini and Harstad (2016)'s model of IEA
- There are many countries, $i \in N$, and infinite periods, $t \geq 1$
- Income (y) from agriculture (L), "clean" goods/services (R), and transfers (τ):

$$y_{i,t} = R_{i,t} + pL_{i,t} + \tau_{i,t},$$

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  where p is relative price of Ag output
- Income is consumed. Utility from consumption is quadratic

$$B(y_{i,t}) = -\frac{b}{2}\left(\overline{y}_i - y_{i,t}\right)^2$$

Model

Depletion dynamics

- Countries are endowed with agricultural land, $L_{i,t}$, and non-productive land (forest), $N_{i,t}$
- Each period, each country decides to deplete $d_{i,t}$, after which

$$N_{i,t} = N_{i,t-1} - d_{i,t},$$

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- Public good: each country receives a global benefit gN_t, where

$$N_t \equiv \sum_{i \in N} N_{i,t}$$

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Clean technology

- The clean technology stock depreciates at the rate $(1 - q_R) \in [0, 1]$
- If a country invests $r_{i,t}$, next period's technology is

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- Investment costs are

$$\kappa(R_{i,t+1}, R_{i,t}) = \frac{k}{2}\left(R_{i,t+1}^2 - q_R^2 R_{i,t}^2\right)$$

(marginal investment costs are proportional to $R_{i,t}$)

Model

Utility

- The utility of country i in period t is

$$u_{i,t} = -\frac{b}{2}\left(\overline{y}_i - pL_{i,t} - R_{i,t} - \tau_{i,t}\right)^2 + gN_t - \frac{k}{2}\left(R_{i,t+1}^2 - q_R^2 R_{i,t}^2\right) e^{-\rho(\Delta-\Lambda)}$$

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- Each country chooses $(d_{i,t}, r_{i,t})$ to maximize

$$\sum_{s=t}^{\infty} \delta^{s-t} u_{i,s}$$

subject to

$$R_{i,t+1} = q_R R_{i,t} + r_{i,t},$$

$$N_{i,t} = N_{i,t-1} - d_{i,t},$$

$$L_{i,t} = L_{i,t-1} + d_{i,t},$$

where $\delta \equiv e^{-\rho\Delta}$.

First-best outcome

Proposition 1: First-best outcome

Let $n = |N|$ be the number of countries and

$$\ell_i^n \equiv \frac{1}{p}\left(\overline{y}_i - ng\left(\frac{1}{b} + \frac{1}{K}\right)\right).$$

The first-best depletion levels are

$$d_{i,t}^C = \ell_i^n - L_{i,t-1}$$

The first-best investment levels are

$$r_{i,t}^C = \frac{ng}{K} - q_R R_{i,t}$$

Moreover, the first-best depletion levels ensure that

1. If $\ell_i^n \leq L_{i,t-1}$, then country i does not deplete anymore ($d_{i,t}^C \leq 0$).
2. If $\ell_i^n \geq N_{i,t-1} + L_{i,t-1}$, then country i depletes the remaining stock: $N_{i,t+s} \xrightarrow{s\to\infty} 0$
3. If $\ell_i^n \in (L_{i,t-1}, N_{i,t-1} + L_{i,t-1})$, then there is partial depletion: $N_{i,t+s} \xrightarrow{s\to\infty} N_{i,t-1} + L_{i,t-1} - \ell_i^n$

Non-cooperative outcome and country heterogeneity

Proposition 2: Non-cooperative outcome (BAU)

The non-cooperative outcome coincides with the first-best outcome iff $n = 1$. That is, the first-best depletion levels are

$$d_{i,t}^{NC} = \ell_i^1 - L_{i,t-1}$$

The first-best investment levels are

$$r_{i,t}^{NC} = \frac{g}{K} - q_R R_{i,t}$$

- Countries with $\ell_i^1 \leq L_{i,t-1}$ conserve unilaterally (in absence of a treaty)
- Countries with $\ell_i^1 > L_{i,t-1}$ deplete unilaterally

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Stage game

Countries play the following stage game

1. Coalition formation stage: Every $i \in N$ decides participation $(i \in M)$. The rest remain independent.

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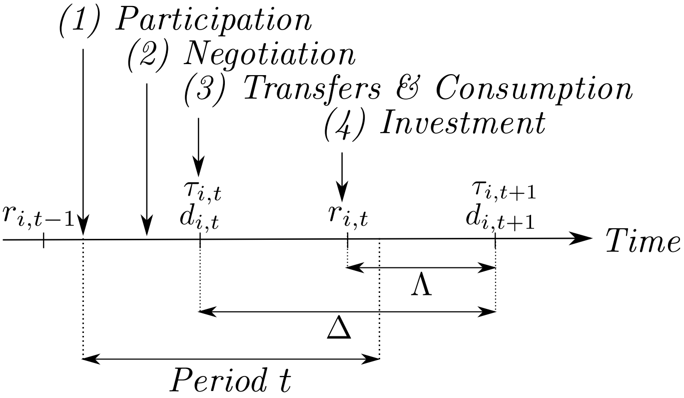
3. Consumption stage: Non participants indep. choose $d_{i,t}$. Coalition members conserve as agreed. Agreed transfers are paid.
4. Investment stage: Non participants indep. choose $r_{i,t}$. Coalition members invest as agreed.

Model

Timing

The timing is as follows



Treaties A and B

- Can $N_{i,t}$ be recovered?
- First, let's assume that $N_{i,t}$ may be recovered (i.e. $d_{i,t}$ may be negative)

Treaty A

- Every country depletes $d^C_{i,t}$
- No transfers

Treaty B

- Every country depletes $d^C_{i,t}$
- Transfers among countries

Proposition 3: Participation in Treaties A and B

The size of any equilibrium coalition is at most 3.

Treaties C and D

- Assume that $N_{i,t}$ cannot be recovered (for political or ecological reasons).
- Countries can at most be required to deplete $d^*_{i,t} = \max\{0, d^C_{i,t}\}$

Treaty C

- Every country depletes $d^*_{i,t}$
- No transfers

Treaty D

- Every country depletes $d^*_{i,t}$
- Transfers among countries

Proposition 4: Participation in Treaty C

If $n_d \ll n_c$, then no coalition is possible.

Proposition 5: Participation in Treaty D

The size of any equilibrium coalition is at most 3.

Treaty E

- Countries receive/donate a transfer τ_i and unilaterally decide $d_{i,t}^{NC}$
- Contributions are voluntary

Proposition 6: Participation and contributions in Treaty E

Participation is full, but contributions are too low and too much is depleted.

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- Bad news for the world!
- No news, really... these results align with the existing literature
  - $\rightarrow$ What do we gain from this analysis?
- Clean investments do not play a major role in this model $\rightarrow$ avenue for future work

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