

Growth and Development: Ecosystem Services, Biodiversity, and Conservation

Jonathan Colmer

University of Virginia

Lecture Notes for PhD Growth and Development (EC8510)

Declining Environmental Inputs and Biodiversity

- ▶ Ecosystems provide services that humans depend on
 - ▶ very difficult to measure and price
 - ▶ are there alternatives?
- ▶ **Key concept:**
 - ▶ If natural inputs decrease, man-made inputs increase
 - ▶ Solow (1993) "Sustainability: An Economist's Perspective"
 - ▶ We know surprisingly little about such patterns of substitution.
- ▶ Theory focuses on measurement and management ([Weitzman, 1992; 1993; 1998; Nehring and Puppe, 2002; Brock and Xepapadeas, 2003](#))
- ▶ Estimating the effects of losses is challenging ([Constanza et al., 1997; Boyles et al., 2011; Cardinale et al., 2012; Naeem et al., 2012; Ando and Langpap, 2018; IPBES, 2019](#))

Pesticides substitute for Natural Pest Control

- ▶ Frank (2024) shows that when bat population decreases, pesticide use increases, which leads to health externalities.
 - ▶ Bats are a major predator of insects – eats over 40% of its body weight in insects each night.
 - ▶ Farmers benefit from biological pest control
 - ▶ There are chemical substitutes – but only 0.1–0.3% of applied pesticides reach target pests.
- ▶ Wildlife disease caused by invasive fungus led to local extinctions in 69% of affected areas (30-100% death rates).
- ▶ Disease unexpectedly appeared in 2006 and spread across counties over time.
- ▶ WNS → 22% ↑ Insecticides → 17% ↑ IMR

Wetlands as Flood Protection

- ▶ Taylor and Druckenmiller (2002) estimate the value of wetlands for flood protection
- ▶ By holding back some of the flood waters and slowing the rate that water re-enters stream channels, wetlands reduce downstream flooding.
- ▶ Clean Water Act (Section 404): permit required to dredge or fill aquatic resources for real estate, infrastructure, mining, or industrial activities
- ▶ Recent Supreme Court ruling on what counts as wetlands led to EPA change in definition, which significantly limited protections.
- ▶ On average, each hectare of wetland lost increased NFIP claims by \$1,840 per year.
 - ▶ In developed areas, claims increased by \$8,290.

The Economics of Conservation

- ▶ Quesnay and the Physiocrats: the foundation of economic activity is grounded in nature.
 - ▶ Only agriculture, fishing and mining are productive.
 - ▶ Other activities convert "free gifts of nature" through labor and capital.
 - ▶ Limitless common pool resource.
- ▶ Resource Management: 'Use' vs. 'Preservation'
 - ▶ Pinchot: Resources should be developed and managed properly to avoid waste.
 - ▶ Preservation (Thoreau, Emerson, Muir): Nature has intrinsic value.
- ▶ Krutilla: 'Conservation Reconsidered'
 - ▶ Preferences for preservation should be accounted for in economic decisions.
 - ▶ Development and conservation both have opportunity costs.
 - ▶ Important to consider irreversibility of development/investments

Economic Activity and Environmental Conservation

- ▶ Human life and economic activity depend on the natural environment.
 - ▶ Where there is limited substitutability between human-made and natural capital, depreciation has large social costs.
- ▶ Improvements in environmental quality typically require controls on economic activity.
- ▶ Regulations must be monitored, enforced, and avoid regulatory capture.
 - ▶ Enforcement is economically and politically costly
 - ▶ Trade-off between costs and benefits of environmental regulation
- ▶ Limited evidence on the enforcement of conservation interventions.

The Ocean as a Target for Conservation

The world's oceans:

- ▶ Are vital for livelihoods and economies:
 - ▶ The largest source of protein;
 - ▶ Directly support the livelihoods of over 3 billion people;
 - ▶ Have a global market value estimated at over \$3 trillion.
- ▶ Deliver non-market benefits:
 - ▶ Produce 50-85% of the world's oxygen;
 - ▶ Sequester almost half of global carbon dioxide;
 - ▶ Harbor much of the planet's biodiversity.
- ▶ Are the largest open-access common-pool resource.

The Tragedy of the Ineffectually Managed Commons

- ▶ The overextraction of unmanaged common-pool resources has been recognized for well over a century.

Forster Lloyd, (1833), Coman (1911), Gordon (1954), Hardin (1968), Ostrom (1990)

- ▶ In the absence of effective regulation over-extraction and environmental degradation occurs.
 - ▶ Biomass of assessed fish stocks has declined by 50% since 1950
 - ▶ As of 2020, 30% of stocks can be classified as collapsed
 - ▶ Coral reef cover is 50% lower today than in 1950 (Eddy 1950)
 - ▶ 38.7% of marine mammals were threatened in 2018 (IPBES 2018)

Managing the Commons: Marine Protected Areas

“A clearly defined geographical space, recognized, dedicated and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values.” - IUCN

- ▶ Very popular:
 - ▶ Average EEZ coverage has increased 10-fold since 2000.
 - ▶ Continuing calls for increase coverage: ‘30x30’, ‘Nature Needs Half’
- ▶ Argued to be one of the most effective ways to recover and restore ocean life
- ▶ Concerns over effective monitoring - “paper parks”

Limited Evidence on Protection

“The shortage of empirical research largely reflects the lack of biological knowledge and data. The consequences of this situation are that policy decisions are resolved in an arena devoid of the benefit (or constraint) of estimates of the economic benefits and costs of alternative courses of action.” - Maurice Wilkinson: AER P&P (1979)

- ▶ Biological knowledge has advanced greatly.
- ▶ Data have lagged behind
 - ▶ This has constrained work on causal inference (Ferraro and Pattanayak 2006; Miteva et al 2012; Ferraro et al. 2019)

Research Question

Have MPAs been effective at controlling economic activity?

What Does Theory Predict?

- ▶ Huge theoretical literature on resource economics and management (Gordon 1954; Scott 1955; Johnson and Libecap 1982; Karpoff 1987; Sanchirico and Wilen 1999; 2001; 2005; Costello et al. 2015)
- ▶ Focus on optimal policy in bio-economic dynamic spatial equilibrium models
- ▶ **Key take-away:** A reduction in economic activity is a necessary condition for delivering benefits.
 - ▶ MPAs must be located in areas that were profitable pre-implementation
 - ▶ MPAs must be monitored and enforced

Empirics

- ▶ **New Data:** Comprehensive data on the location and activity of $> 70,000$ commercial fishing vessels world wide.
- ▶ **Analysis:**
 1. Do MPAs reduce fishing activity at the border? - spatial RDD of 153 MPAs.
 - ▶ On average, we estimate a 14-19% reduction in fishing activity at the boundary.
 2. Do MPAs reduce fishing activity overall? - Identifying RDD effects away from the cutoff (Angrist and Rokkanen, 2015)
 - ▶ On average, we estimate 34-40% reduction in fishing activity inside MPAs.
 3. Projected conservation outcomes differ significantly based on protection:
 - ▶ Biomass improvements are $\sim 5\times$ larger under full protection than estimated protection.
 - ▶ Catch levels recover more quickly under estimated protection, but are higher in the long term under full protection.

What are the Constraints to Conservation?

- ▶ **Political:** Weak governance means that actual extraction levels are not the same as what the law says
- ▶ **Poverty:** What does poverty imply for conservation? Should we pay people to conserve?
- ▶ **Technological:** Limited access to or adoption of sustainable technologies can hinder conservation efforts.
- ▶ **Cultural:** Local customs and traditions may conflict with conservation goals
- ▶ **Economic:** Conservation often requires financial investment, which competes with other pressing economic priorities. How does market structure/competition affect conservation?
- ▶ **Information:** A lack of data or knowledge about ecosystems and their value can lead to poor decision-making and reduced public support for conservation initiatives.

Deforestation in Brazil

- ▶ Amazon is the world's largest tropical forest – more than 2 million square miles
- ▶ Between 2000 and 2020, 55% of global forest loss has come from the Brazilian Amazon.
- ▶ Until 2005, penalties for “infractions” (not felony) were weak and not seriously enforced.
- ▶ Brazil increased enforcement starting in 2005, strengthening fines and increasing enforcement using satellites.
- ▶ Burgess et al. (2023) study what happens at the border.

The Border



The gap between *de facto* action and *de jure* rules

- ▶ Comparing deforestation at the border captures the effect of state policy, holding constant other factors like profitability, soil, etc.
- ▶ Level differences indicate the differences are due to being Brazil.
- ▶ Sharp changes over time indicate tightening of enforcement.
- ▶ Paper says State policy can play a role in determining wedge between *de facto* and *de jure* conservation policy.
- ▶ Other interesting work on political competition and electoral cycles.