Climate and Biodiversity

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Each affects the other

Climate affects biodiversity

Biodiversity affects climate

Analytically they raise similar issues

Climate ⟶ Biodiversity

Sea level rise destroys coastal ecosystems

Coral reefs, mangroves, Great Barrier Reef, …

Reefs are important as fish nurseries and also as storm barriers – many studies attempt to place a value on tropical reefs

Temperature change affects species' viability in current locations

Animals moving habitat north up to10 miles/decade on land, 17 miles/decade in oceans

Situations where northward movement isn't possible – encounter coast or conurbation - polar bears

Plants moving northwards too, 3-4 miles/decade

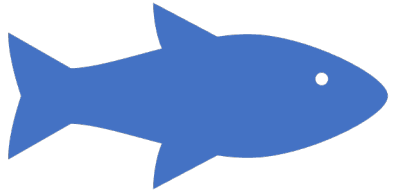
Wildfires destroy forests and species

Climate change destroys synchronization

Extinction mechanisms

Climate ⟶ Biodiversity

Glaciers lose mass threatening irrigation – Latin America and SE Asia

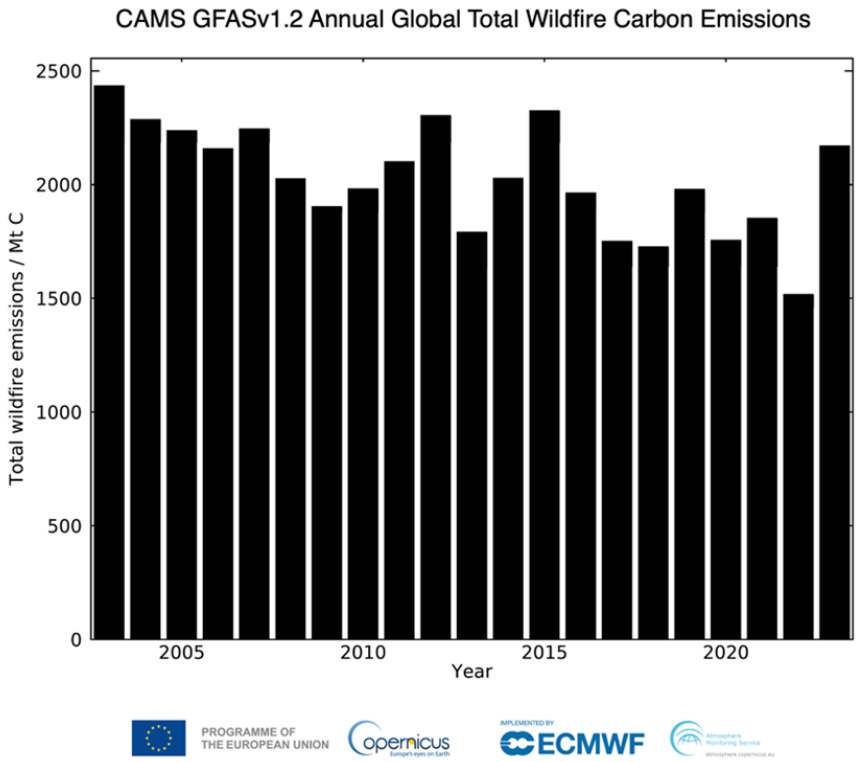


Warmer oceans lead to less productive fisheries – higher ocean temperatures reduce MSYs

Synchronization

- Pied Flycatcher
  - 5 inch long, migrates between N Europe & W Africa every year – crossing Sahara, Mediterranean, Alps
  - Departure from W Africa triggered by length of day
  - Arrival in N Europe used to coincide with emergence of insect grubs
  - Emergence of grubs now occurs several weeks earlier and can't feed itself and its offspring on these – starvation
  - Many similar examples of climate change disrupting ecosystem functioning
  - Humming birds and flower pollination

BD → CC



Deforestation destroys biodiversity- & contributes to CC

Wildfires – caused in part by CC – contribute to CC

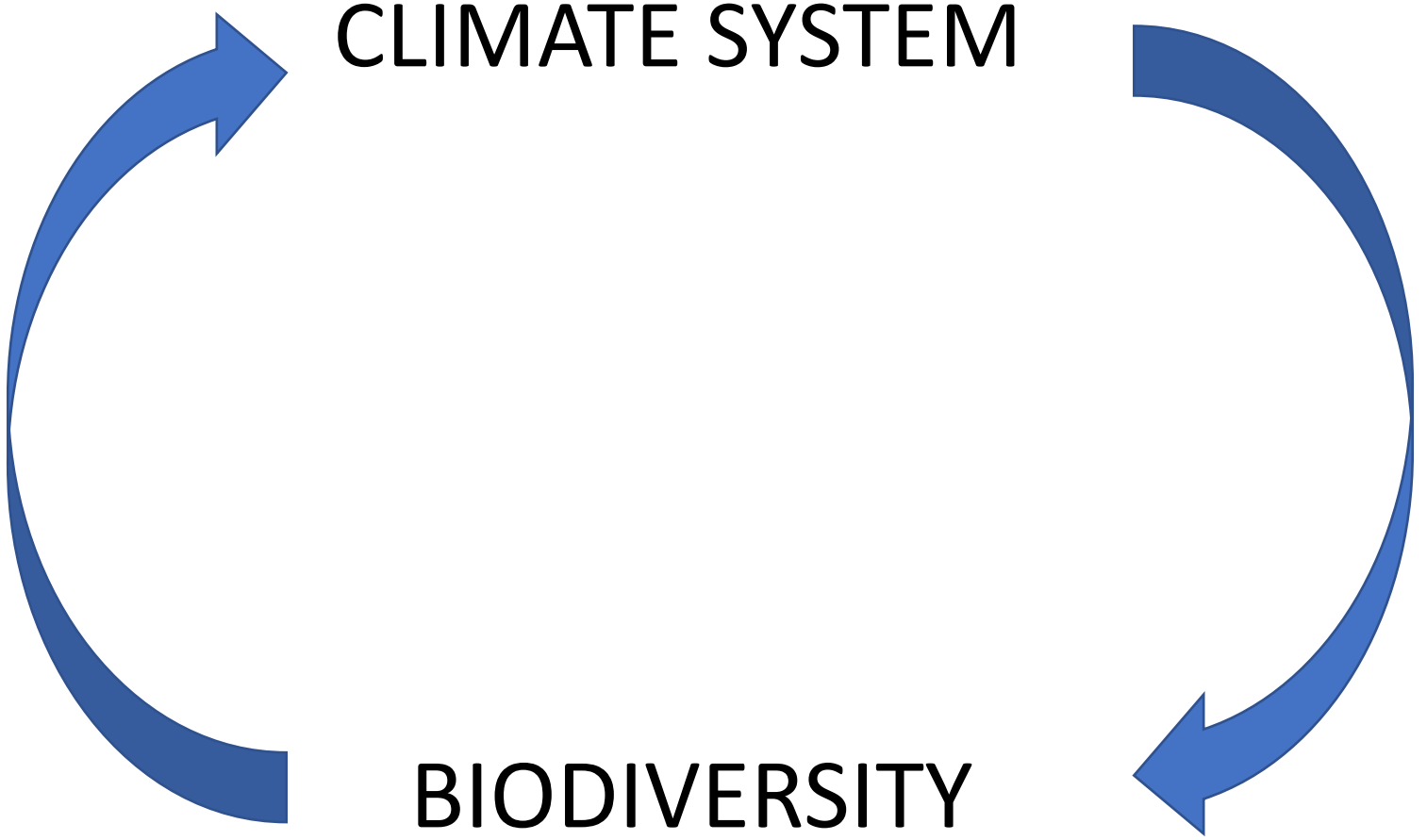
Wildfire emissions about 8bn tons CO2/yr

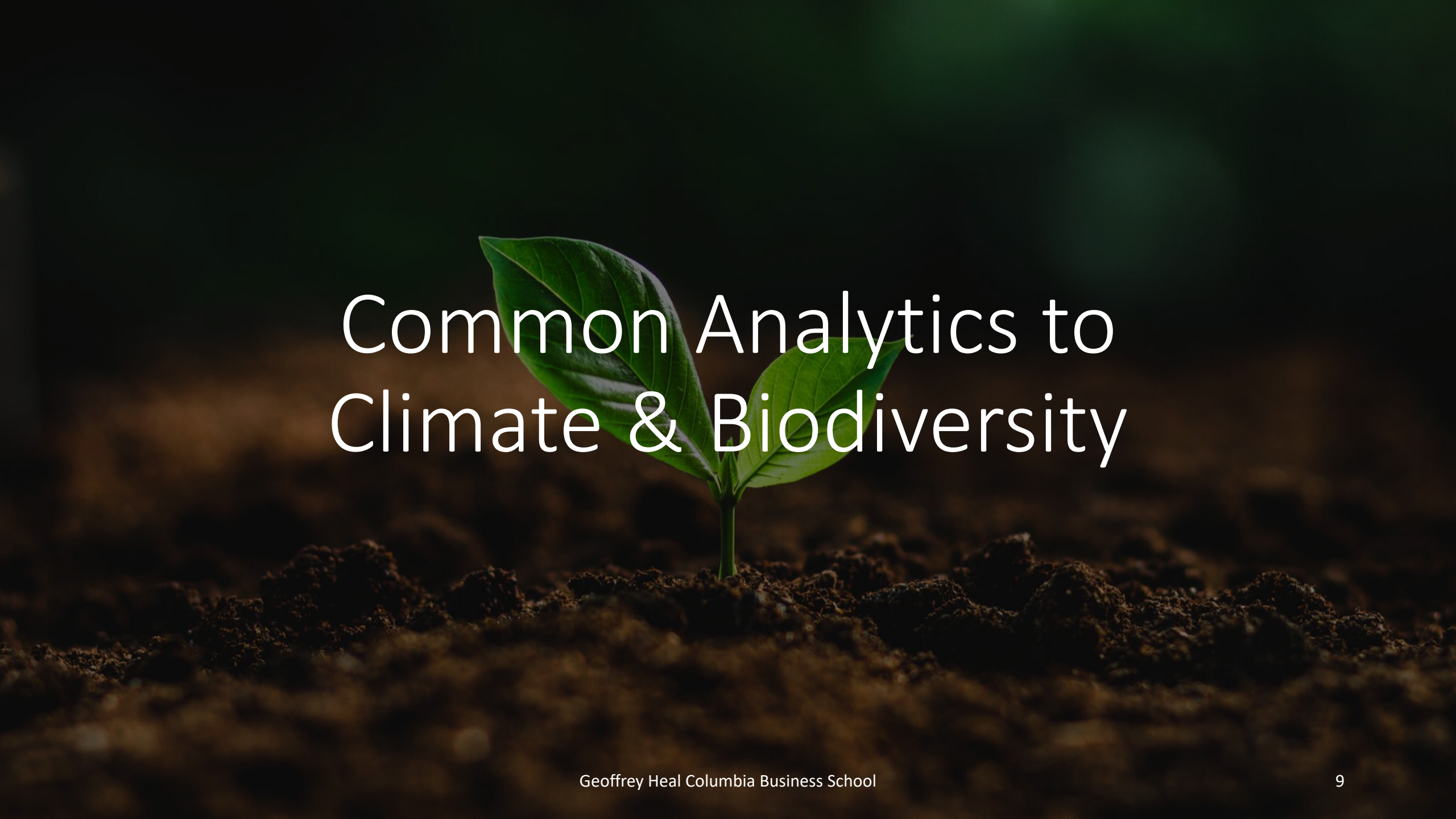
Pine bark beetles destroy BD and contribute to CC

Loss of keystone species

Can lead to radical changes in ecosystem, with impact on climate

Loss of sea otters → growth of sea urchin population → destruction of kelp beds → release of CO_2


CLIMATE SYSTEM
BIODIVERSITY



Common Analytics to Climate & Biodiversity

Attributes of Climate & Natural Capital

- **Biodiversity/Natural capital & climate system can last for ever** – forests will absorb CO2 as long as they exist, Catskills watershed has managed NYC's water supply as long as the city has existed and will continue for ever – no depreciation. **Long time horizon.**
- **Destruction/Alteration is irreversible**. Generally, can't recreate biodiversity/natural capital once it's destroyed or reverse climate change. Extinction is forever!
  - Deforestation is irreversible as it leads to chemical changes in soil and also to changes in local climate
  - Destruction of US NE cod population – regulation has not allowed cod populations to rebound

Attributes

Ecosystem services & climate services are generally public goods

- Knowledge of molecular structures from bioprospecting – *knowledge a classic public good*
- Climate stability from forests and sequestration of CO2
- Pollinator services are a public good

We don't have a good model of how policies affect outcomes

- Central banks have reasonably widely-accepted models of how QE affects the macroeconomy
- For biodiversity/climate conservation, many weak models of how policies affect human welfare

Dynamics of Climate & Biodiversity

- Highly complex
- Multiple regimes
- Tipping points – associated with irreversible changes

Implications – time horizon

- **Long time horizon** means choice of discount rate is crucial. Benefits 100+ years ahead are annihilated by conventional discount rates and so much of the value of the asset is lost
- To value conserving an extra increment of BD we need to use the consumption discount rate not the pure rate of time preference
- $\frac{dln\{U_c e^{-\delta t}\}}{dt}$ not δ. This is $\rho = \delta + \eta \frac{\dot{C}}{C}$ where $\eta = -c \frac{U_{cc}}{U_c}$
- But suppose $U = U(C, S)$ where S is state of environment or measure of biodiversity

Discount rates

- Suppose utility is a function of two variables – consumption and environmental stock S: $U(C,S)$
- Then we have two cdrs, ρ_C & ρ_S given by

- $\rho_C = \dfrac{\partial\left(U_C\left(C_t,S_t\right)e^{-\delta t}\right)/\partial t}{U_C\left(C_t,S_t\right)e^{-\delta t}} = \delta + \eta_{CC}\dfrac{\dot{C}}{C} + \eta_{CS}\dfrac{\dot{S}}{S}$
- $\rho_S = \dfrac{\partial\left(U_S\left(C_t,S_t\right)e^{-\delta t}\right)/\partial t}{U_S\left(C_t,S_t\right)e^{-\delta t}} = \delta + \eta_{SS}\dfrac{\dot{S}}{S} + \eta_{SC}\dfrac{\dot{C}}{C}$

Implications

- Then $\rho_S = \delta + \eta_{SS}\frac{\dot{S}}{S} + \eta_{SC}\frac{\dot{C}}{C}$ as the rate of change of U_S depends on level of C
- For CES utility $\eta_{SS} > 0$ and η_{SC} is positive or negative as the elasticity of substitution is >1 or <1. Likely that $\frac{\dot{S}}{S} < 0, \frac{\dot{C}}{C} > 0$ so it is possible that $\rho_S < \delta$
- Choosing δ is controversial – several paradigms
  - Look to the market
  - Objective, benign planner
  - Social choice

Choosing a discount rate

- Probably $\dot{C}/C > 0$ and $\dot{S}/S < 0$. $\eta_{CC} > 0$ but sign of η_{CS} depends on whether C, S are complements or substitutes
- If S is falling and $\eta_{CS} > 0$ then this term reduces the CDR
- There is a connection between these two rates

The marginal rate of substitution between C and S at time t - the price ratio - is $U_S(C_t, S_t)/U_C(C_t, S_t)$ and the rate of change of this is

$$\frac{\partial (U_S/U_C)/\partial t}{U_S/U_C} = \frac{\dot{S}}{S}\{\eta_{CS} - \eta_{SS}\} + \frac{\dot{C}}{C}\{\eta_{CC} - \eta_{SC}\} = \rho_C - \rho_S \qquad (8)$$

Environmental Discount Rate

Likely that marginal value of environment is rising relative to that of consumption goods

Environment becomes scarcer over time, and IED of WTP for environment > 1

So $\frac{\partial(\frac{U_S}{U_C})/dt}{U_S/U_C} > 0$ so $\rho_C > \rho_S$ and the CDR exceeds the EDR

Drupp et al

INSIGHTS | POLICY FORUM

SCIENCE GALLEY

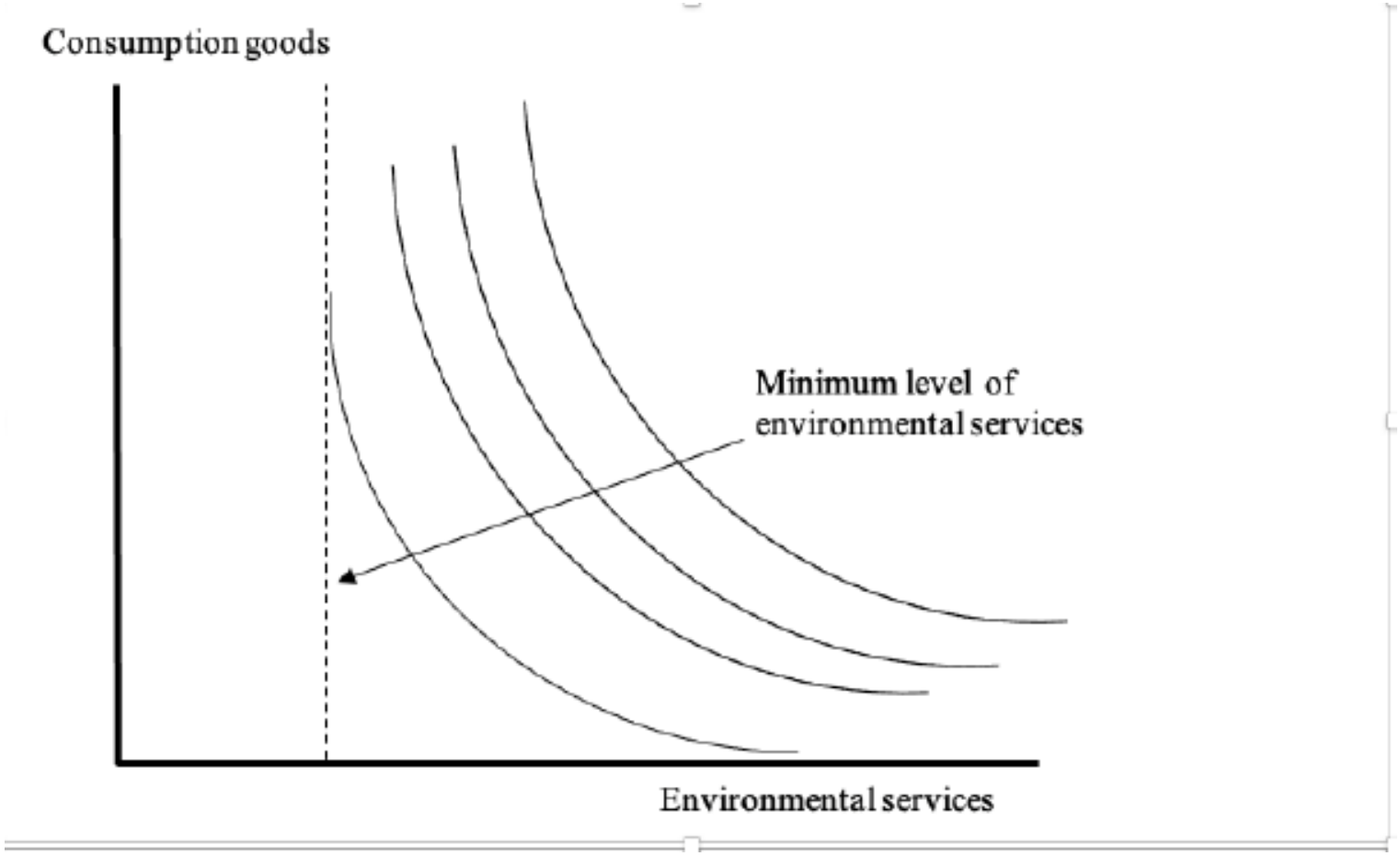
ENVIRONMENTAL ECONOMICS

Accounting for the increasing benefits from scarce ecosystems

As people get richer, and ecosystem services scarcer, policy-relevant estimates of ecosystem value must rise

By M.A. Drupp*[,1], M.C. Hänsel[2,3], E.P. Fenichel[4], M. Freeman[5], C. Gollier[6], B. Groom[7,8], G.M. Heal[9], P.H. Howard[10], A. Millner[11], F.C. Moore[12], F. Nesje[13], M.F. Quaas[2,14], S. Smulders[15], T. Sterner[16], C. Traeger[17], F. Venmans[8]

Natural Capital & Human Welfare

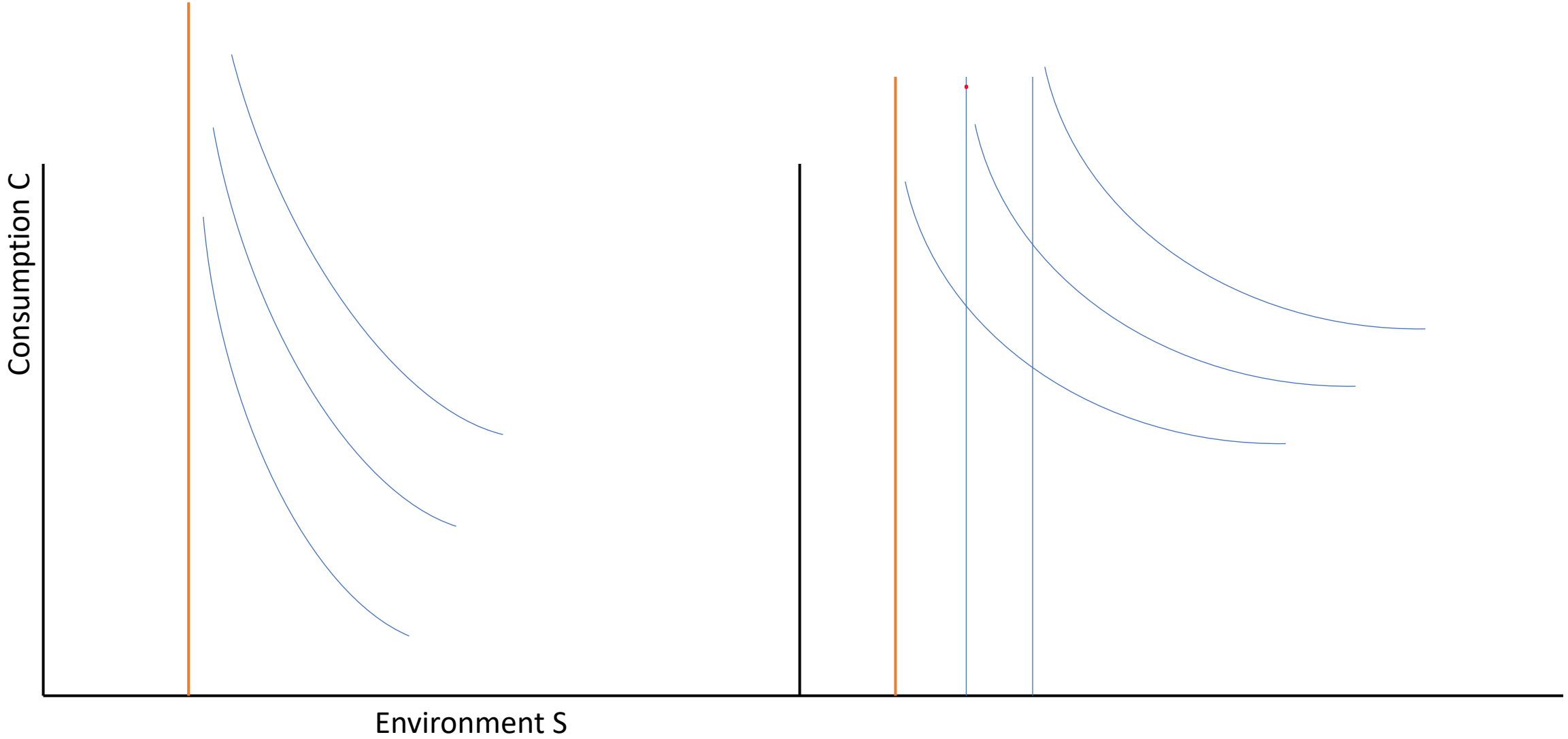


C and S

- $[\alpha C^{\sigma} + (1-\alpha)S^{\sigma}]^{1/\sigma}$ a CES utility function in C and S.
- If $\sigma > 1$ C and S are complements and vice versa
- Suppose there is a minimum level of environmental/climate services we need to survive – see figure. Then we have
- $[\alpha C^{\sigma} + (1-\alpha)(S-\varepsilon)^{\sigma}]^{1/\sigma}$

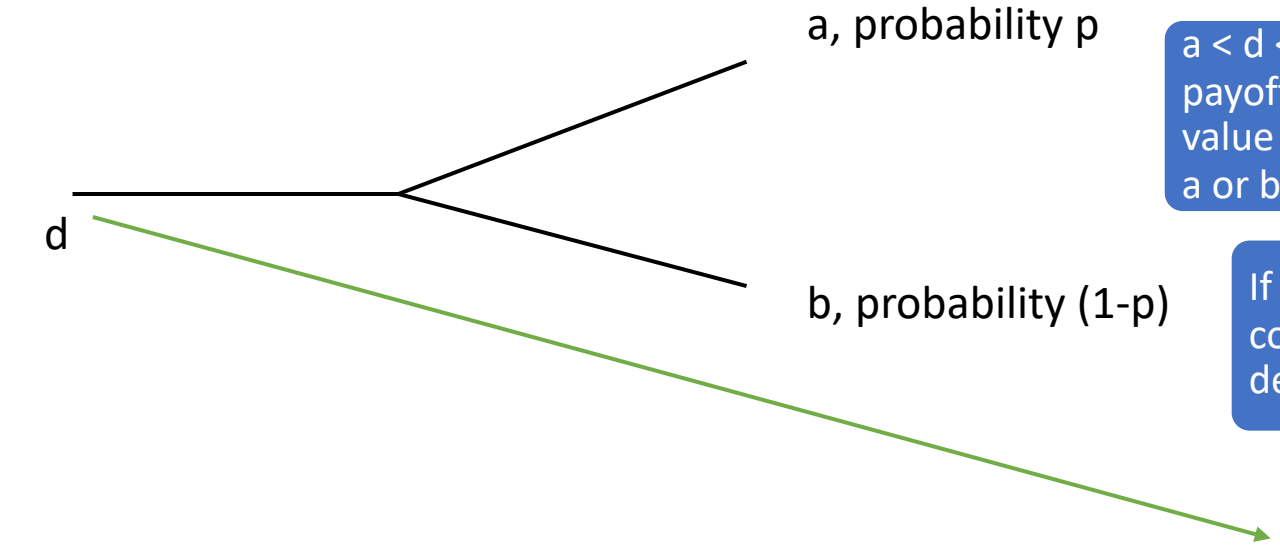
Welfare, C & S

- Two possible cases –
- There exists a min level of $S, \tilde{S}$ for human existence and all C-S isoquants asymptote to this
- For each welfare level $\widehat{U}$ $\exists$ $\hat{S}$: $isoquant\ \widehat{U(C,S)}$ asymptotes to $\hat{S}$


Consumption C
Environment S

Implications - irreversibility

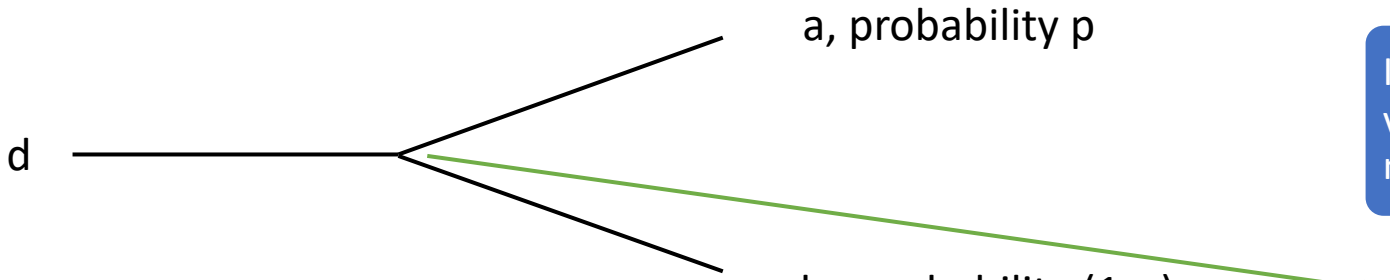
- The combination of irreversibility, uncertainty and the possibility of learning raise the threshold for policy choices that damages natural capital or the climate
- Implies the existence of a quasi-option value associated with conservation
- Means that the expected payoff to conservation understates the value of conservation



a < d < b. Develop land at t = 0 for payoff of d or leave in which case value as biodiversity reserve is either a or b, known only at t = 1.

If decision is made at t = 0 then one compares d with p.a + (1-p).b and develops iff d > p.a + (1-p).b.

Return is max{d, p.a + (1-p).b}



If decision is delayed till t = 1 then value a or b is known. Develop if b, not if a.

Return is max{d,b} >= max{d, p.a+(1-p).b}

t = 0 t = 1

Public goods

Well-known that markets don't allocate public goods efficiently.

Why? Because an extra unit of the good benefits everyone. With the standard individualistic utility function, I will be willing to pay for the benefits to me but won't consider the benefits to everyone else.

Hence under-provision from a social perspective

How to resolve this problem?

Two approaches

Incentive mechanism design. When I increase the amount of the public good, I benefit everyone else but am not rewarded for this – I generate a positive externality for everyone

Internalize this by paying me for the benefits I generate for others – the Clarke-Groves-Vickery mechanism

Problems with this mechanism – government expenditure exceeds revenues

Two approaches

Suppose instead of the usual individualistic utility function people place value on the wellbeing of others

Then they will value the benefits they convey to others by supporting the public good

With sufficient interpersonal solidarity or empathy public goods will be provided efficiently

Bundling public & private goods

Safaris in S or E Africa are big business. What guests pay for is transport and accommodation in tents - may pay $20,000+ for a week

They are willing to pay so much to stay in a tent because of the presence of biodiversity – lion, elephants, leopards, rhinos, hippos,etc

The organizers are not just selling tented accommodation – they are selling that bundled with access to biodiversity

The BD or natural capital – a public good - raises the willingness to pay for the accommodation – so bundling a public good with a private raises the WTP for the private and can be good business

PROPOSITION 1: *If utility functions are strictly concave and the cost function strictly convex, then a profit-maximizing producer who provides a private and a public good and can practice first-order price discrimination will provide an economically efficient combination of the public and private goods.*

Bundling public & private goods

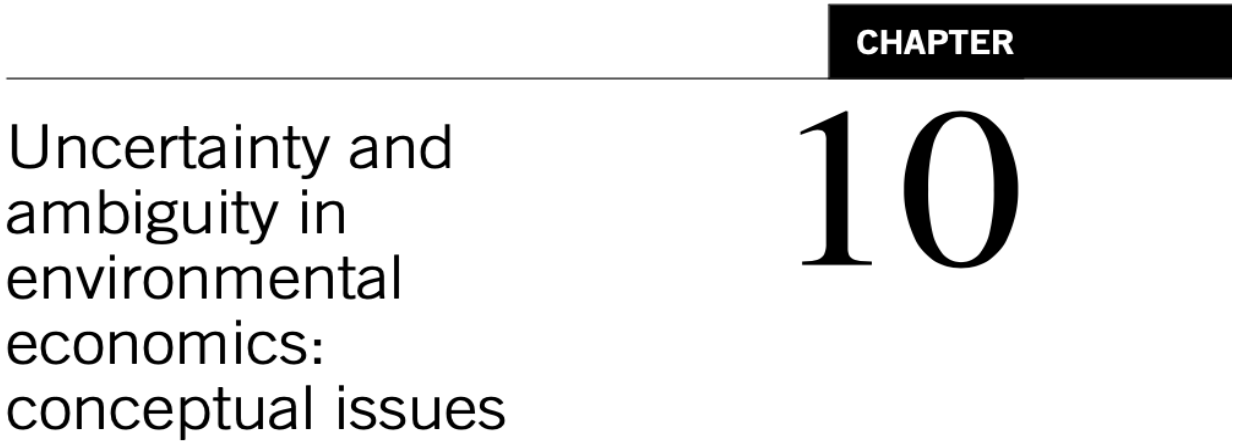
- The safari business is an illustration of this proposition – that it can be profitable for the seller of a private good to provide and bundle with it a public good
- If the seller is a discriminating monopolist, it can lead to an efficient outcome

No good models

- We know that BD affects human welfare but don't have a compelling model of how this occurs
- Several different models of this relationship, each giving a different map from policy choices to welfare outcomes
- How to act given this uncertainty – we have a "multiple priors" situation
- Growing literature suggests two dominant approaches

No good models: *Scientific uncertainty*

- MaxMin Expected Utility – evaluate each policy alternative according to the model that makes it look worst (Gilboa-Schmeidler)
- Evaluate choices by a non-linear weighted average of outcomes according to the the alternative models (Klibanoff Marinacci Mukherji)
- Both involve some degree of focus on worst-case outcomes not unlike the precautionary principle



CHAPTER

10

Uncertainty and ambiguity in environmental economics: conceptual issues

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Data availability

Sharp difference –

Climate well-documented and measured

Temperature, precip, wind, humidity, …..

Biodiversity/Natural capital suffers from a paucity of data

We have data on forest cover, vegetation, some fish stocks, but little else. Also World Bank data on wealth accounting

Summary:

CC and loss of NC interact strongly and reinforce each other

Pose analytically similar problems

But data on natural capital is sadly lacking