Transition Goals and Integrated Assessment Models

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Transitions in human history

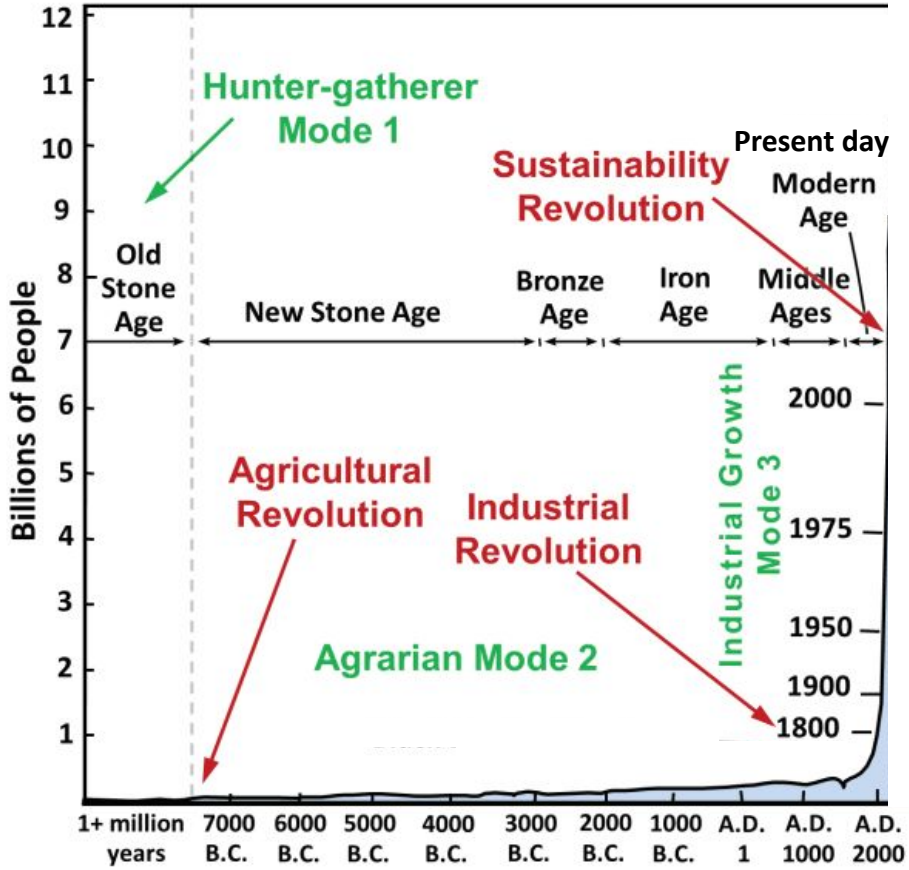


Image credit: pg. 394
Common Property Rights: A Process Driven Approach to Solving the Complete Sustainability Problem
Jack Harich *Lulu Press* (2011)
https://www.thwink.org/sustain/publications/books/03_CommonPropertyRights/CommonPropertyRights_Ebook.pdf

The causal chain of climate damage tells us what the goal looks like

$M^{it.\ demand}$ $M^{it.\ supply}$ R^{emoval} $R^{eflection}$ $A^{daptation}$

FF Production→FF Consumption→GHGs→Forcing→Warming→Damage

Schematic idea from Drake et al. *Enviro. Res. Lett.* 2021

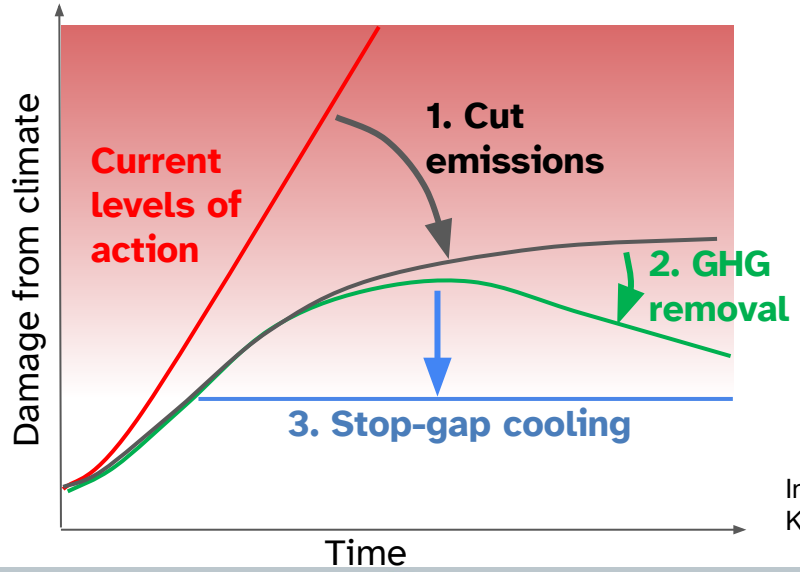


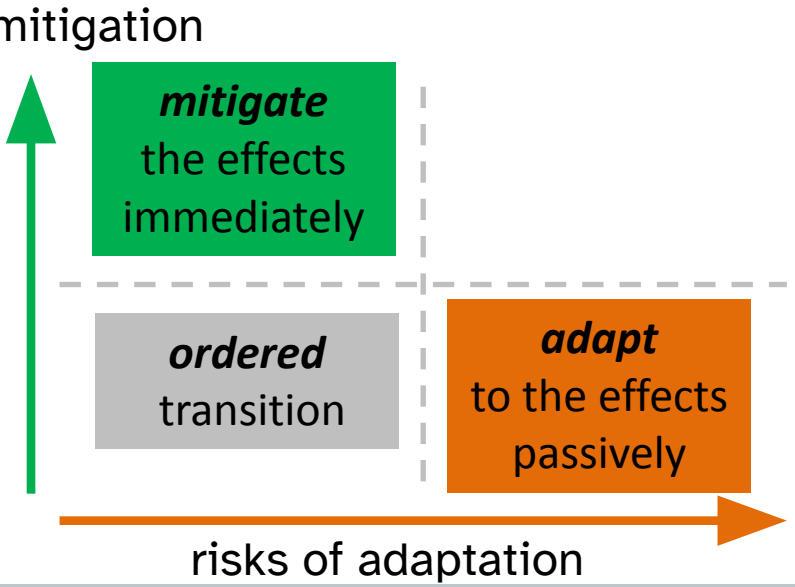
Image idea from MacMartin & Kravitz *PNAS* 2018

Having a damage goal is not enough: Need preferences for socio-economic pathways

- Same climate state can arise from very different socio-economic trajectories
- A prescriptive goal demands specifying what is a desirable socioeconomic trajectory, in addition to the climate we want.
- Economists and financial planners have an outsized influence on institutions' investment goals
- They often consider ***optimal plans*** in which '*desirable*' is operationalized

Transitioning to *Net-zero* emissions, *by design or disaster*

mitigation and *adaptation*



Must place a $-value on all activities?!

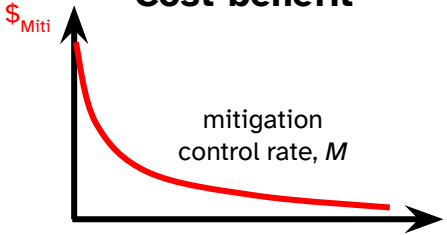
mitigation planning analyses

Cost-benefit

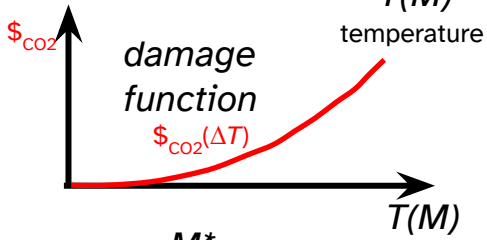
Welfare Maximization

Cost effectiveness

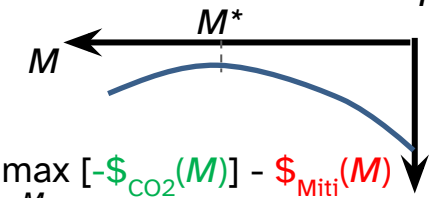
Mitigation costs



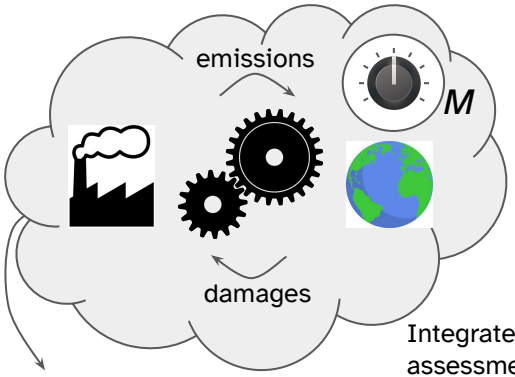
Mitigation benefits (avoided damages)



Optimization objective

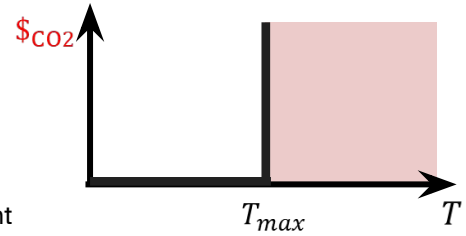


$$\max_{M} [-\$_{CO2}(M)] - \$_{Miti}(M)$$



Integrated assessment model (IAM)

Consumption → Utility → $\max_{M}$ Value(M)



$$\min_{M} \$_{Miti}(M)$$

subject to: $T(M) \leq T_{max}$

Can also combine CBA and CEA (*c.f.* Schultes *Environ Res Lett* 2021)

Defining *Value* – *expected discounted return*

- What is welfare? Happiness? Economists use *consumption-based utility*.
- Welfare for who? – ***social welfare*** definitions
- What is **action space** of a policy, *i.e.* what knobs are controllable?
- What are the sum of future utilities (benefits and costs) given a policy & current state?
- What climate/human/corporate uncertainty is there? Just take the average.
- How to discount future benefits/costs? What time horizon into the future?

Integrated Assessment Models

- economics and climate models integrated in the 1990s
  - Economy component
    - *Damage function*: economic cost due to temperature changes
    - Output: emissions from production
  - Climate component
    - *Climate sensitivity*: temperature change due to changes in GHG concentration
    - Output: Temperature changes
- Beware! climate-economic coupling not well understood
  - more *ad hoc* assumptions than in climate modelling
  - Pessimistic: IAMs are so flawed currently, it's dishonest to promote their policy validity

    The Use and Misuse of Models for Climate Policy Pindyck *NBER* 2015
    - Economic modelling itself debated: the validity of existing *microfoundations* of macro
  - Optimistic: Defendable use cases. Focus on improving IAM practice.

    Some Contributions of Integrated Assessment Models of Global Climate Change Weyant 2017

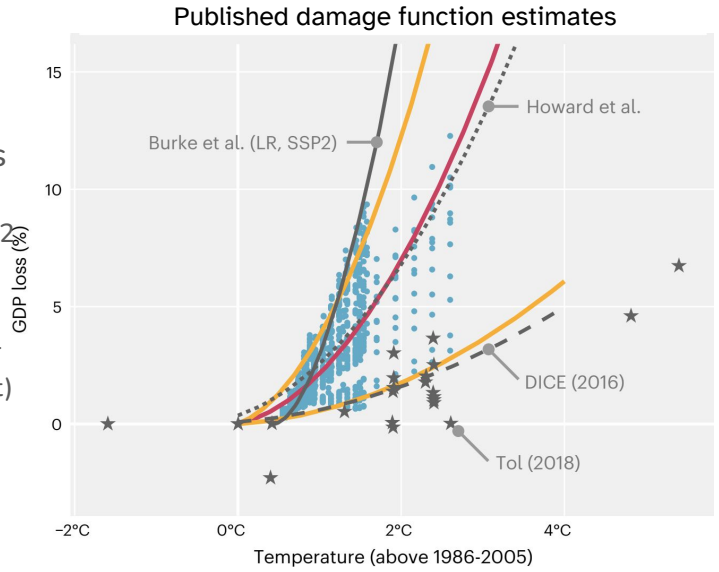
Taxonomy & history of IAMs

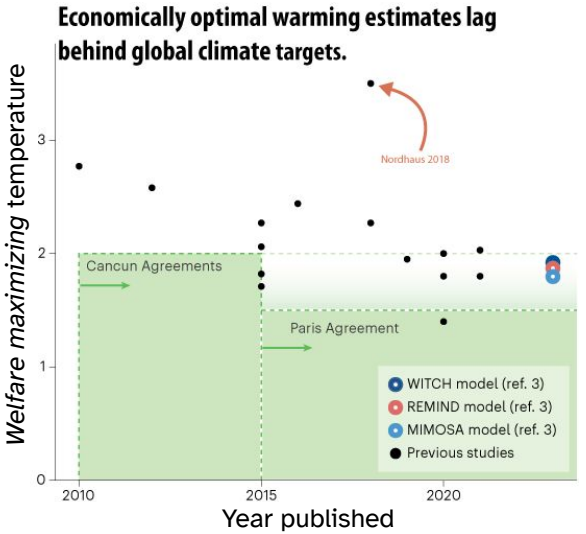
- Policy: mitigation parameters over time
  - Policy Optimization (e.g. DICE/RICE)
  - Policy Evaluation (test a given a policy)
- General/Partial Equilibrium Model (national/sectoral)
  - Dynamic variants (e.g. REMIND - Ramsey type)
- Newer versions
  - Dynamic stochastic general equilibrium models
    - Include exogenous shocks
    - Still highly criticized (Solow's *smell test*)
  - Computable General equilibrium: include more detailed/empirical pricing dynamics
- Agent-based models: all macroeconomics is emergent
  - Nascent approach not yet well developed. Computationally expensive.

Farmer *et al*. *Environ Resource Econ* (2015)

Short-comings of IAM practise

- *Ad hoc* counterfactual damage function families
- Slow development cycle
- Narrow range of outcomes/risks
  - The missing risks of climate change. Rising et al. *Nature* 2022
  - Weitzman *Rev Econ Stat* 2009
- Econ issues
  - Equilibrium & rational behaviour assumptions (Solow's smell test)
- Absence of models of money, finance & banking
- Insufficient validation

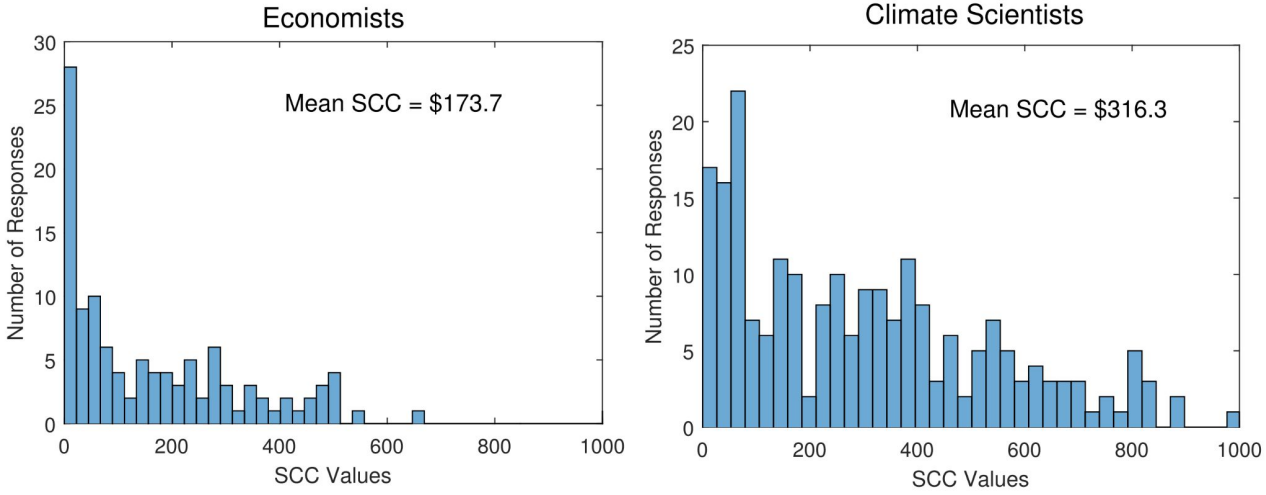




Kikstra & Weidelich Nature 2023

More reliable alternatives to IAMs?

Expert Advice. But who to ask? Estimates (e.g. SCC) by experts depend on research field.



http://web.mit.edu/rpindyck/www/Papers/SCCRevisitedJEEM2019.pdf

Soliciting estimates of **S**ocial **C**ost of **C**arbon (**SCC**) from experts shows differences between economists and climate scientists

How to aggregate expert opinion to average out personal bias? See next tutorial on SSPs!

How sensitive are IAM results?

Go see for yourself using the simple DICE model!

- Utility function: elasticity?
- Temporal discounting: discount factor?
- Damage functions: nonlinearity?

Video Summary

- IAMs are limited, yet accessible projection tools.
- They involve hard science and ethics and need more validation to ensure reliability.
- Improvements are underway, e.g.
  - Science: climate feedback loops
  - Ethics: social welfare functions