

*Valuing the impacts of climate  
change on terrestrial ecosystem  
services*

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Resources for the Future

Improving the Assessment and Valuation of Climate Change  
Impacts for Policy and Regulatory Analyses

Capital Hilton, Washington, DC

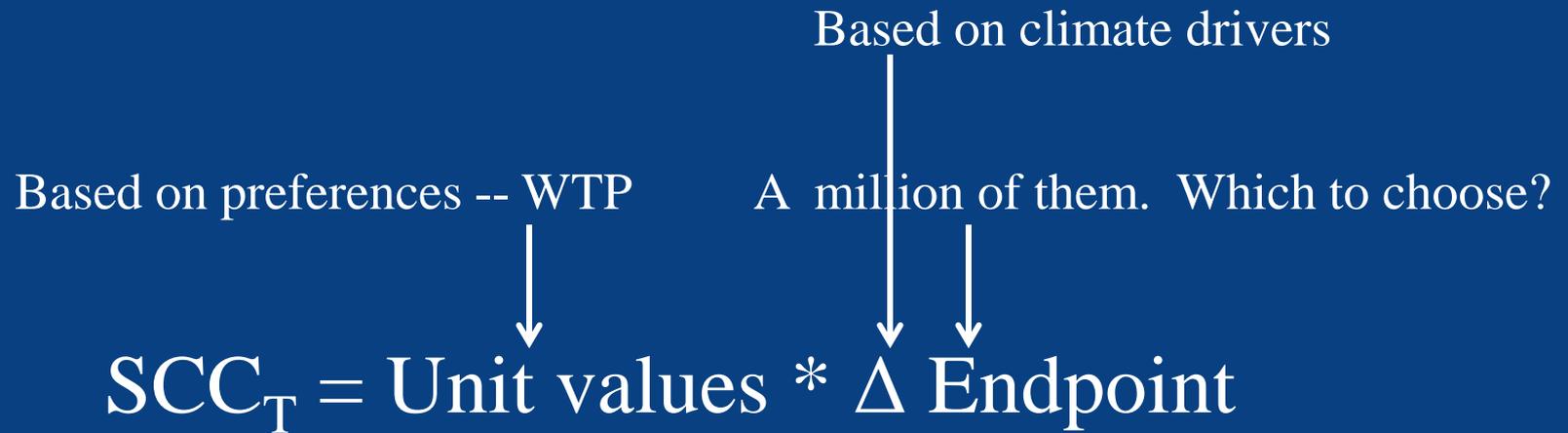
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# Definitions and scope

- Terrestrial: everything but coastal and ocean
- Here, my focus is on the squishiest of ecosystem services: non-use values
  - Stated preference (survey-based) studies. A low WTP per person goes a long way!
- Endpoints: biophysical effects estimated by natural scientists that are used as startpoints in valuation studies

# The task



Need to match

- Natural scientists respond to their drivers
- Economists have no consensus on what to measure → no harmonization, huge variance

# Issues

- Does the natural science examine the appropriate endpoints and build the appropriate functional relationships to link back to climate variables and interventions?
- Are those endpoints valued? Credibly valued? Are the valuation studies comprehensive enough?

# ENDPOINTS AT ISSUE:

## IPCC

Global mean annual temperature change relative to 1980-1999 (°C)

0 1 2 3 4 5 °C

### WATER

Increased water availability in moist tropics and high latitudes ————▶

Decreasing water availability and increasing drought in mid-latitudes and semi-arid low latitudes ————▶

Hundreds of millions of people exposed to increased water stress ————▶

### ECOSYSTEMS

Up to 30% of species at increasing risk of extinction ————▶ Significant<sup>†</sup> extinctions around the globe

Increased coral bleaching ———▶ Most corals bleached ———▶ Widespread coral mortality ———▶

Terrestrial biosphere tends toward a net carbon source as:  
~15% ———▶ ~40% of ecosystems affected ▶

Increasing species range shifts and wildfire risk

Ecosystem changes due to weakening of the meridional overturning circulation —▶

## CONSTITUENTS OF WELL-BEING

### ECOSYSTEM SERVICES



LIFE ON EARTH - BIODIVERSITY

#### Security

- PERSONAL SAFETY
- SECURE RESOURCE ACCESS
- SECURITY FROM DISASTERS

#### Basic material for good life

- ADEQUATE LIVELIHOODS
- SUFFICIENT NUTRITIOUS FOOD
- SHELTER
- ACCESS TO GOODS

#### Health

- STRENGTH
- FEELING WELL
- ACCESS TO CLEAN AIR AND WATER

#### Good social relations

- SOCIAL COHESION
- MUTUAL RESPECT
- ABILITY TO HELP OTHERS

#### Freedom of choice and action

OPPORTUNITY TO BE ABLE TO ACHIEVE WHAT AN INDIVIDUAL VALUES DOING AND BEING

Source: Millennium Ecosystem Assessment

**ARROW'S COLOR**  
Potential for mediation by socioeconomic factors

- Low
- Medium

**ARROW'S WIDTH**  
Intensity of linkages between ecosystem services and human well-being

- Weak
- Medium

# Ecological Production Theory

- Same thing
  - Biophysical **inputs**
  - Transformed via natural processes into
  - Biophysical **outputs**

$$Q_i = f(I_{i1}, I_{i2}, \dots)$$

# Production Function Error

- What is the value of “more acres of eagle habitat?”
- Need to know two things
  - (1) The value you place on eagle abundance 
  - (2) The production function that translates eagle habitat into eagles 

Respondents will intuit a relationship  
But won't know magnitude

# Startpoint Categories for Climate Change

- Use (e.g., fish populations)
- “Standard” non-use (e.g., single species population change, extinction)
- Combinations associated with events (e.g., wildfires) or broad scale changes (e.g., desertification)
- Novel changes (e.g., range shift, mass extinctions)

# Valuation studies classification

- Studies valuing relevant commodities in non-climate context
- Studies transferring these values to a climate change context
- Studies valuing relevant commodities in a climate change context
- Stated preference top-down studies

# Standard Endpoints

**Please vote:**

The following vote offers a choice between *No Program* and an *Improvement Program* option. The **future conditions** of the SAM Region by 2019 for each choice are summarized below. What is your vote?

	No Program	Improvement Program
 <b>Streams and fish</b>	<p>150,000 healthy streams; 150,000 streams of concern.</p> <p>Up to 6 species of fish harmed in streams of concern.</p>	<p>20% of all streams (60,000 streams of concern) will improve and be stocked with these fish.</p>
 <b>Bird populations</b>	<p>Three songbird species are 65% of what they once were.</p>	<p>Three songbird species improve to 85% of what they once were.</p>
 <b>Forests</b>	<p>3% (780,000 acres) of SAM Region has damage to red spruce and sugar maple trees.</p>	<p>1% of SAM Region (260,000 acres) improves</p>
<b>Your additional state tax</b>	<p>\$0</p>	<p>\$500 in total (\$50 per year for 10 years)</p>

<b>Your Vote?</b>	<input type="checkbox"/>	<input type="checkbox"/>
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Murray  
River  
Watershed

Boyle et al,  
2010

		<b>Option A</b> Current Condition	<b>Option B</b>	<b>Option C</b>
Native fish		10% of original population	20% of original population	40% of original population
Healthy Riverside Vegetation and Wetlands		50% of original area  <i>178,000 ha</i>	60% of original area  <i>200,000 ha</i>	70% of original area  <i>240,000 ha</i>
Frequency of Waterbird breeding		Every 10 years	Every 8 years	Every 3 years
Coorong and Lower Lakes		Coorong declining rapidly	Coorong healthy	Coorong declining rapidly
Time until improvement occurs			5 years	20 years
Household cost <i>per year for 10 years</i>	\$	\$0	\$100	\$250

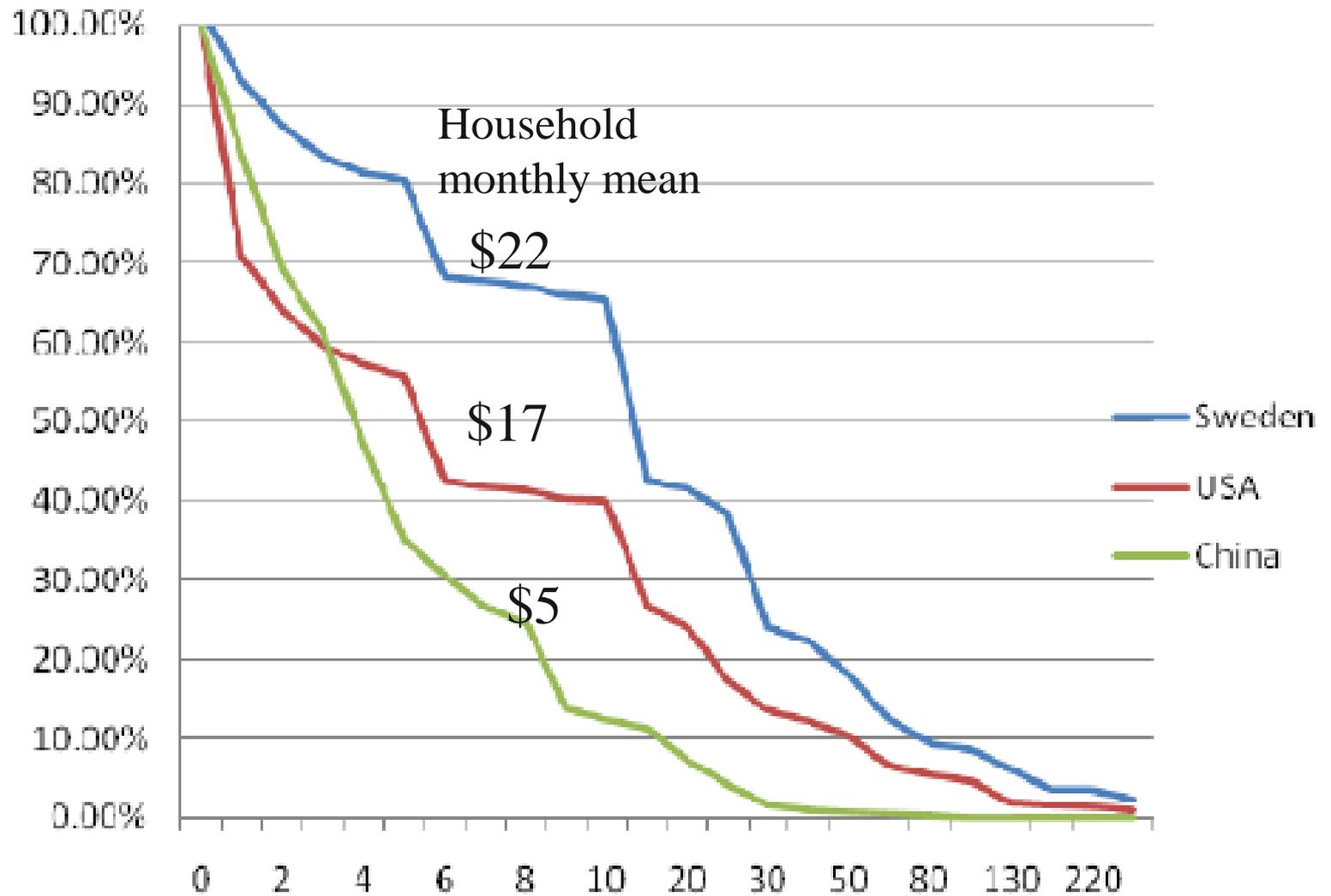
Fleischer and Sternberg, Ecol. Econ, 2006

<u>Program 1</u> No action	<u>Program 2</u> Forestation is used to slow down greenhouse effect	<u>Program 3</u> Reduction in the use of greenhouse gases	<u>Program 4</u> Forestation and greenhouse-gas reduction	<u>Program 5</u> Drastic reduction in greenhouse gases
Landscape in the Galilee <sup>a</sup> will become arid, also loss of plant life will occur	Landscape in the Galilee <sup>a</sup> will become semiarid	Landscape in the Galilee <sup>a</sup> will become semiarid	Landscape in the Galilee <sup>a</sup> will have less plant life	Landscape in the Galilee <sup>a</sup> will not change
\$0 per month Mesic Mediterranean	\$7.5 per month Mesic Mediterranean	\$7.5 per month Mesic Mediterranean	\$15 per month Mesic Mediterranean	\$20 per month Mesic Mediterranean
				
Arid 	Semiarid 	Semiarid 	Mediterranean 	

**Table 1. Global Emission Reduction, Temperature Increase, and Its Effects as Presented to Survey Respondents**

<b>Global emissions reduction</b>	<b>85% reduction</b>	<b>60% reduction</b>	<b>30% reduction</b>
<b><i>Temperature increase</i></b>	2°F increase	3°F increase	4°F increase
<b><i>Harvest</i></b>	Harvests in countries near the equator decrease by 4-6%. Harvests in countries in the northern hemisphere increase by 1-3%.	Harvests in countries near the equator decrease by 10-12%. Harvests in countries in the northern hemisphere are unaffected.	Harvests in countries near the equator decrease by 14-16%. Harvests in the northern hemisphere decrease by 0-2%.
<b><i>Increased flooding and storms</i></b>	Small tropical islands and lowland countries (for example, Bangladesh) experience increased flooding and storms.	Additional low-lying areas in the Americas, Asia, and Africa experience increased flooding and storms.	Populous cities face increased flood risks from rivers and ocean storms. Existence of small island countries is threatened.
<b><i>Threatened ecosystems</i></b>	Sensitive ecosystems, such as coral reefs and the Arctic, are threatened.	Most coral reefs die. Additional sensitive ecosystems and species around the world are threatened.	Sensitive and less-sensitive ecosystems and species around the world are threatened.

**Figure 1. Distribution of WTP Responses for 30% Greenhouse Gas Reduction**



# Usefulness of literature

- Existing “non-climate” studies – useful but limited
- BT with above studies: artificial and assumption-based
- Climate-driven studies: useful, growing literature, but will always be “patchy”

# Top-level studies as tempting option

- Broad coverage of endpoints and locations
- But highly imprecise commodity definitions and scenarios
- What's the alternative?
  - Perhaps benefits transfers from well-done climate-based valuation studies.



# Results

- Most cells filled in → a lot of studies to work with for meta-analyses and benefit-transfer

# Spatial Scale

- Studies range widely in spatial scales
- Desire for specificity to enhance credibility:
  - “tangible” commodities and convincing scenarios

# Scope Sensitivity

- WTP more for avoiding larger damages/gaining larger benefits
- Decreasing marginal returns

# Timing

- Timing of benefits doesn't seem to matter much
- Low discount rates
- Not addressed by many studies

# Uncertainty

- Most assume certainty
- Very few vary uncertainty
- Admitting to uncertainty may induce protest bids
  - Rejection of science or survey
  - Difficult to sort out from “legitimate” responses

# What is needed

- From Ecologists: Endpoints that match valuation startpoints and have functional relationships with climate drivers
- From Economists: consensus approach to classifying endpoints to be used as valuation startpoints

# Final thoughts

- Should surveys mention climate change?
  - Climate skeptics
- How to admit uncertainties in surveys?
- Need holistic valuation estimates (more than just terrestrial ecosystem effects) – no presumption of additivity → top down SP studies? Or top down SP studies for non-market ES only?