The Long View: Developing a New Decision-making framework based on the IPCC's "Iterative Risk-Management" Paradigm

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Assessing the Benefits of Avoided Climate Change

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I will be Taking the Charge (from Jay) Seriously

- Why is risk-management an alternative (a necessary complement) to traditional benefit-cost calculations?
  - Suggest that they can cope with “thorny issues” (thick tails, attitudes toward risk, multiple metrics and missing economic estimates….)
  - Illustrate straightforwardly and comparably how mitigation (and adaptation) can reduce risk in diverse contexts
  - Show how mitigation cost as insurance premia
- In passing, I will reflect briefly on the social cost of carbon (and other greenhouse gases)

Context: Major Lessons from the Fourth Assessment Report (2007)

- Adaptation is unavoidable because the planet would be committed to more warming even if emissions of greenhouse gases were halted today.
- Achieving no concentration target will guarantee limiting temperature increases below any specific threshold.
- **Responding to climate change involves an *iterative risk management process* that includes *both adaptation and mitigation* and takes into account climate change *damages, co-benefits*, sustainability, equity, and attitudes to risk** – deconstructing this conclusion is the topic of my white paper for this meeting**.**

Underlying Themes for Thinking Practically about Responding to Climate Change

- Uncertainty is ubiquitous – risk is what matters.
- Risk is Probability times Consequence
- Risk expressed in terms of vulnerabilities (not just exposures) can be a common denominator for decision-makers even if the metrics are not the same
- Risk management is the most appropriate policy lens and can provide methods for prioritizing research initiatives and policy decisions (even when benefit-cost calculations are possible)
- Focusing on risk broadens the perspective beyond "high confidence" vulnerabilities and provide strong evidence that timing is important.

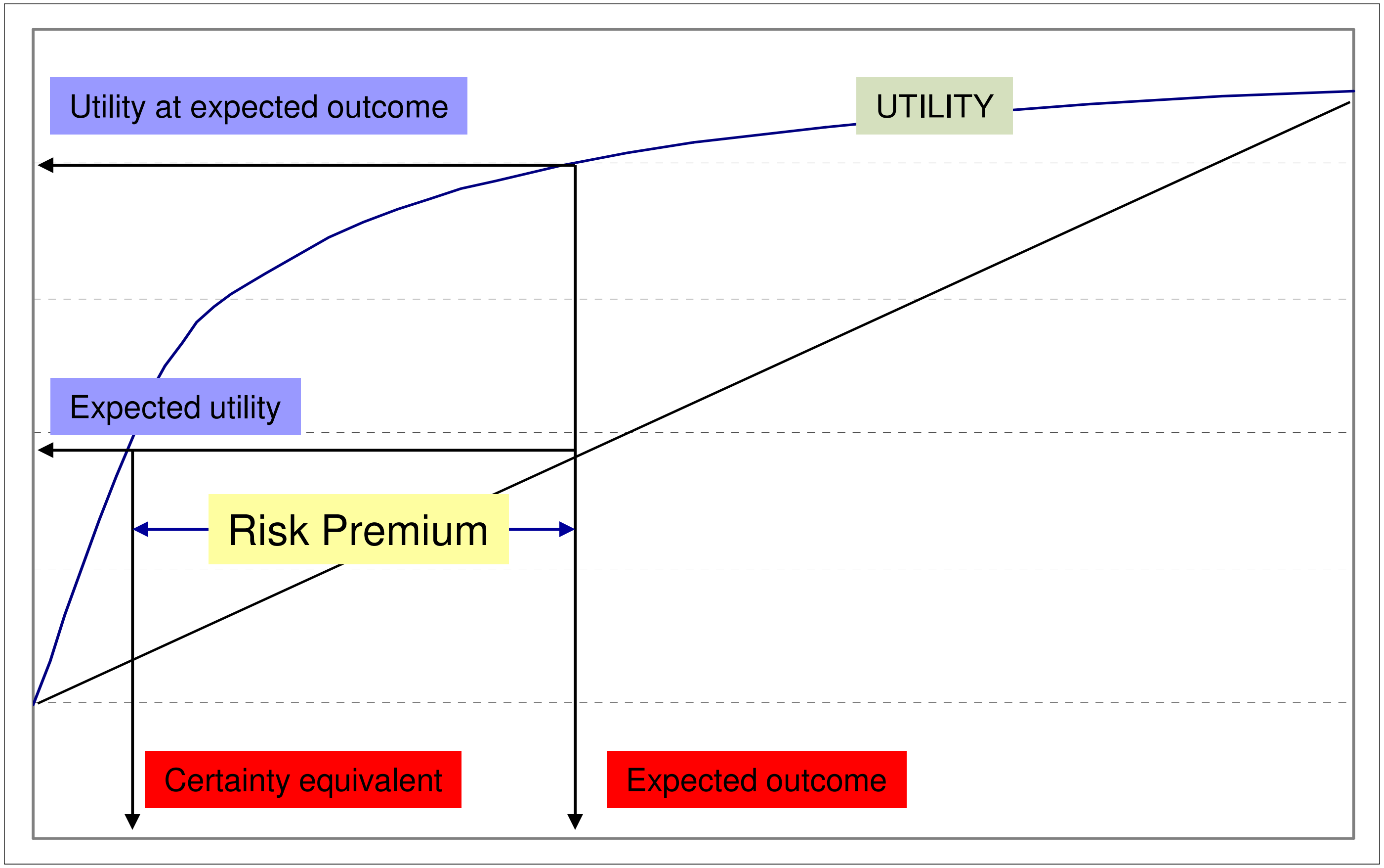
Some Fundamental Concepts

- When we know a lot about both probability *and* consequence, “expected value” of risky outcomes can be used to communicate information to decision-makers.
- This is approach used in most benefit-cost analyses; it can rigorously reflect the value of mitigation, but only if actuarially fair insurance is available.
- Risk management approaches are especially useful when consequences are non-linear with respect to exposure and/or exposure is non-linear with respect to the driving forces – even if precise information is sparse.
- Note in passing - risk management supports the economic efficiency validation of diversification, hedging, and insurance.

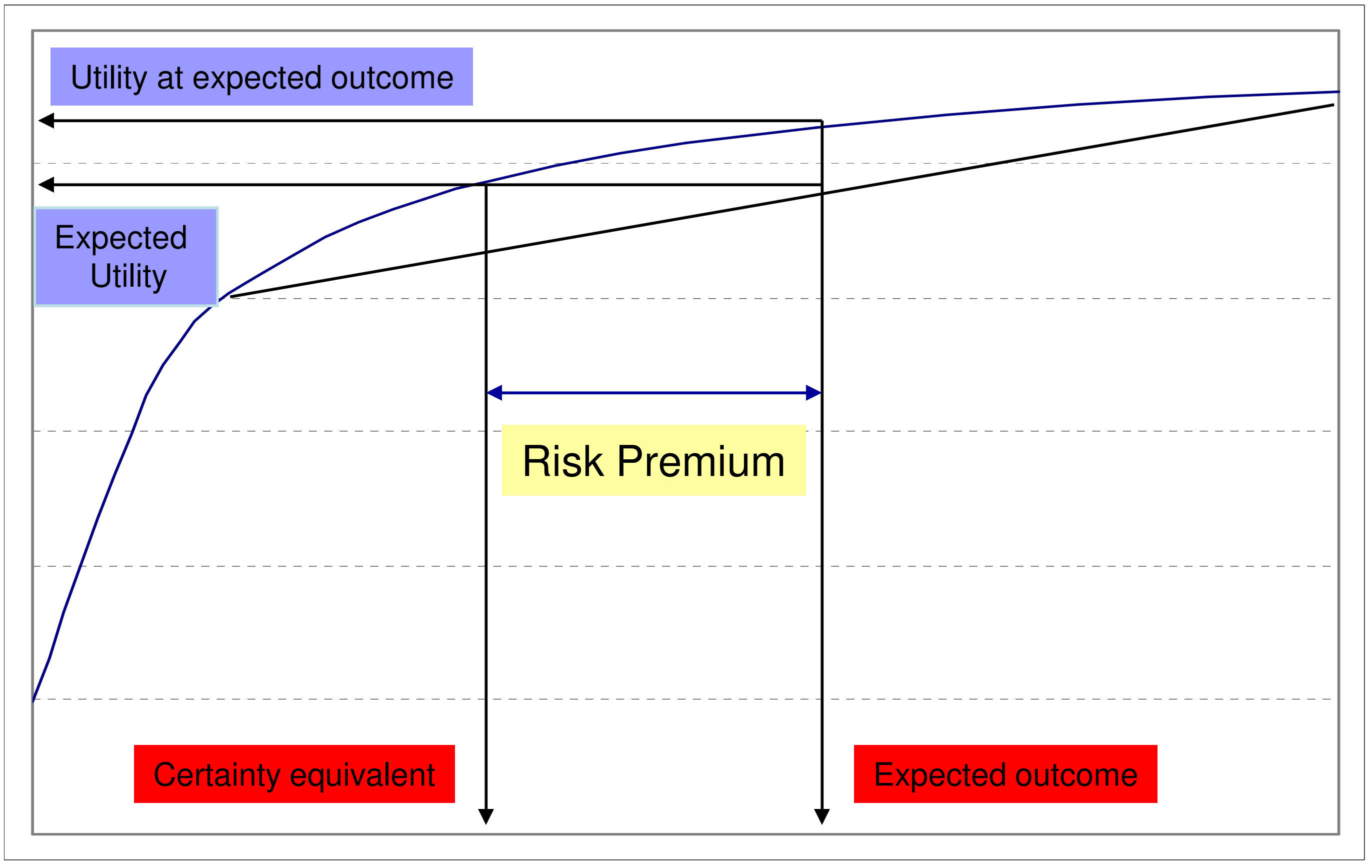
Comparative Strengths of "Risk Management" Approach

- Risk management approaches are particularly helpful when:
  - There is substantial uncertainty (temporal, spatial, or otherwise) even about the probabilities of events.
  - Actors are risk-averse – so simple expected value calculations and/or representations of "most-likely" scenarios do not adequately inform appropriate decisions (in the absence of appropriately priced insurance).
  - There are fundamental uncertainties that will simply not be resolved in a timely fashion (e.g., climate sensitivity, socio-economic site specific development pathways, etc…).

An Illustration:
Nonlinearity and Aversion to Risk



Continuing the Illustration: Mitigation Cost and Insurance Premia



Interpreting the Graphs

- Differences in certainty equivalents are the appropriate comparative metrics for judging the value of mitigation unless actuarially fair insurance exists. In that case, differences in expected outcomes work fine.
- Risk neutrality (linear utility) eliminates the difference between expected outcome and certainty equivalence; there are then NO risk premia.
- The efficacy of adaptation and/or mitigation can be reflected as changing either relative likelihoods and/or consequences (reduce harm or enlarge benefits by changing exposures and/or sensitivities).

For Example – What Stern Could have Done

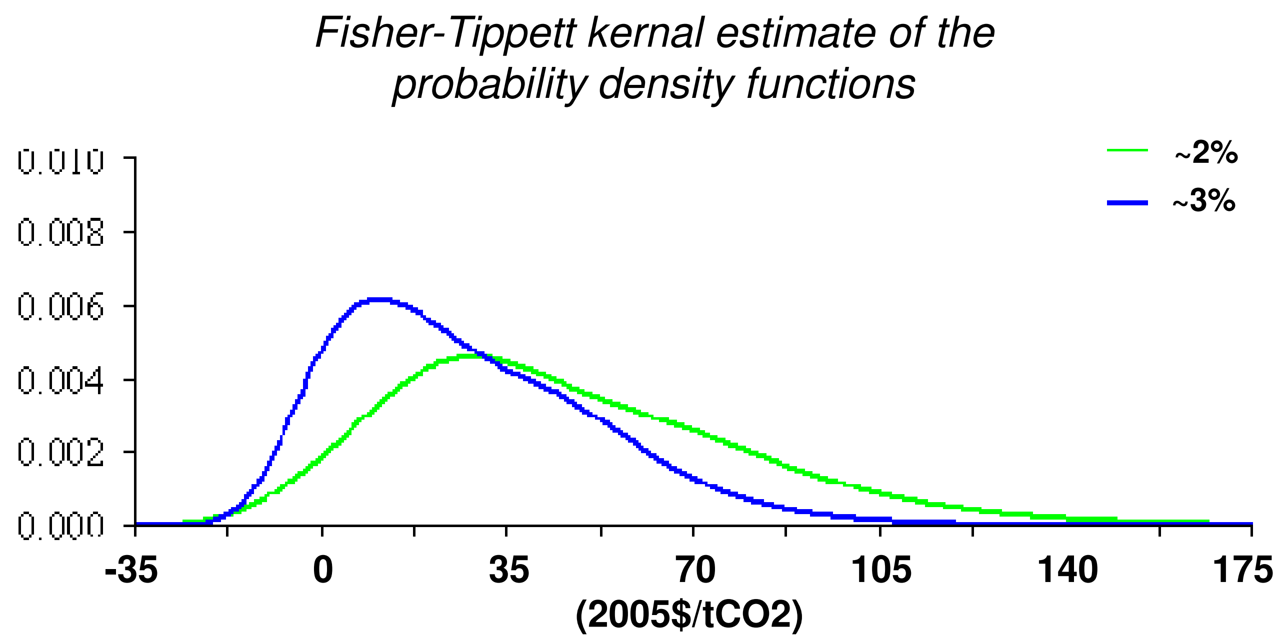
Table 1: Estimates of residual economic damage along least-cost mitigation pathways from the S
et al (2006) baseline expressed in terms of certainty equivalent per capita consumption; source: To
and Yohe (2009)

Atmospheric Concentration	Δ Certainty Equivalent Per Capita Consumption
unregulated	-5.3%
750 ppm	-3.8%
700 ppm	-3.4%
650 ppm	-3.0%
600 ppm	-2.6%
550 ppm	-2.2%
500 ppm	-1.7%
450 ppm	-1.3%
400 ppm	-0.8%

Aggregate Estimates of Damages: The Social Cost of Carbon

- Discounted damages associated with the emission of an extra ton of carbon at a specific point in time.
- It can be an indication of a long-term objective since, along an optimal path, it should be set equal to the price of carbon (e.g., a tax)
- But, it is very difficult to make operational because estimates are very dependent on normative assumptions about time preference, risk aversion and inequality aversion; also very dependent on uncertainties like “climate sensitivity”.
- Important to note that it is time specific and future dependent.

Refined meta analysis range
(for emissions reductions in 2005)



Selected Sources for the Dispersion

Table 20.2. *Major factors causing uncertainty in the social cost of carbon. Relative importance is measured by the magnitude of the partial rank correlation coefficient between the parameter and the SCC, with the most important indexed to 100. A + sign shows that an increase in this parameter leads to an increase in the SCC and vice versa. Source: Hope (2005).*

Parameter	Definition	Sign	Range	Importance
Climate sensitivity	Equilibrium temperature rise for a doubling of CO_2 concentration	+	1.5 to 5°C	100
PTP rate	Pure time preference for consumption now rather than in 1 year's time	-	1 to 3% /yr	66
Non-economic impact	Valuation of non-economic impact for a 2.5°C temperature rise	+	0 to 1.5% of GDP	57
Equity weight	Negative of the elasticity of marginal utility with respect to income	-	0.5 to 1.5	50
Climate change half life	Half life in years of global response to an increase in radiative forcing	-	25 to 75 years	35
Economic impact	Valuation of economic impact for a 2.5°C temperature rise	+	-0.1 to 1.0% of GDP	32

Note: non-economic and economic impact ranges apply to Europe; impacts in other regions are expressed as a multiple of this.

Summary of EPA estimates

(various emissions years and discount rates, 2006$)

		~ 2%			~ 3%			~ 7%		
		Low	Central	High	Low	Central	High	Low	Central	High
Meta global	2007	-3	68	159	-4	40	106	n/a	n/a	n/a
	2017	-2	91	213	-3	53	142	n/a	n/a	n/a
	2022	-2	105	247	-2	62	165	n/a	n/a	n/a
	2030	-1	134	314	-2	78	209	n/a	n/a	n/a
	2040	-1	179	421	-1	105	281	n/a	n/a	n/a
FUND global	2007	-6	88	695	-6	17	132	-3	-1	5
	2017	-4	118	934	-4	23	178	-2	-1	7
	2022	-4	136	1083	-4	26	206	-2	-1	9
	2030	-3	173	1372	-3	33	261	-1	0	11
	2040	-2	232	1843	-2	44	351	-1	0	15
FUND domestic	2007	0	4	16	0	1	5	0	0	0
	2017	0	6	22	0	1	7	0	0	0
	2022	0	7	26	0	2	9	0	0	0
	2030	0	9	32	0	2	11	0	0	0
	2040	0	12	44	0	3	15	0	0	0

FUND estimates are preliminary

- Estimates for reductions in subsequent years are higher due to a larger marginal effect on net damages (IPCC suggests 2-4%/yr; 3% applied above)
- DOT and DOE proposed rule estimates: \$7/tCO_2 in 2011 (2006\$), range \$0 - \$14

The Relative Importance of Time Preference and Risk (Inequality) Aversion

- Ramsey discounting:

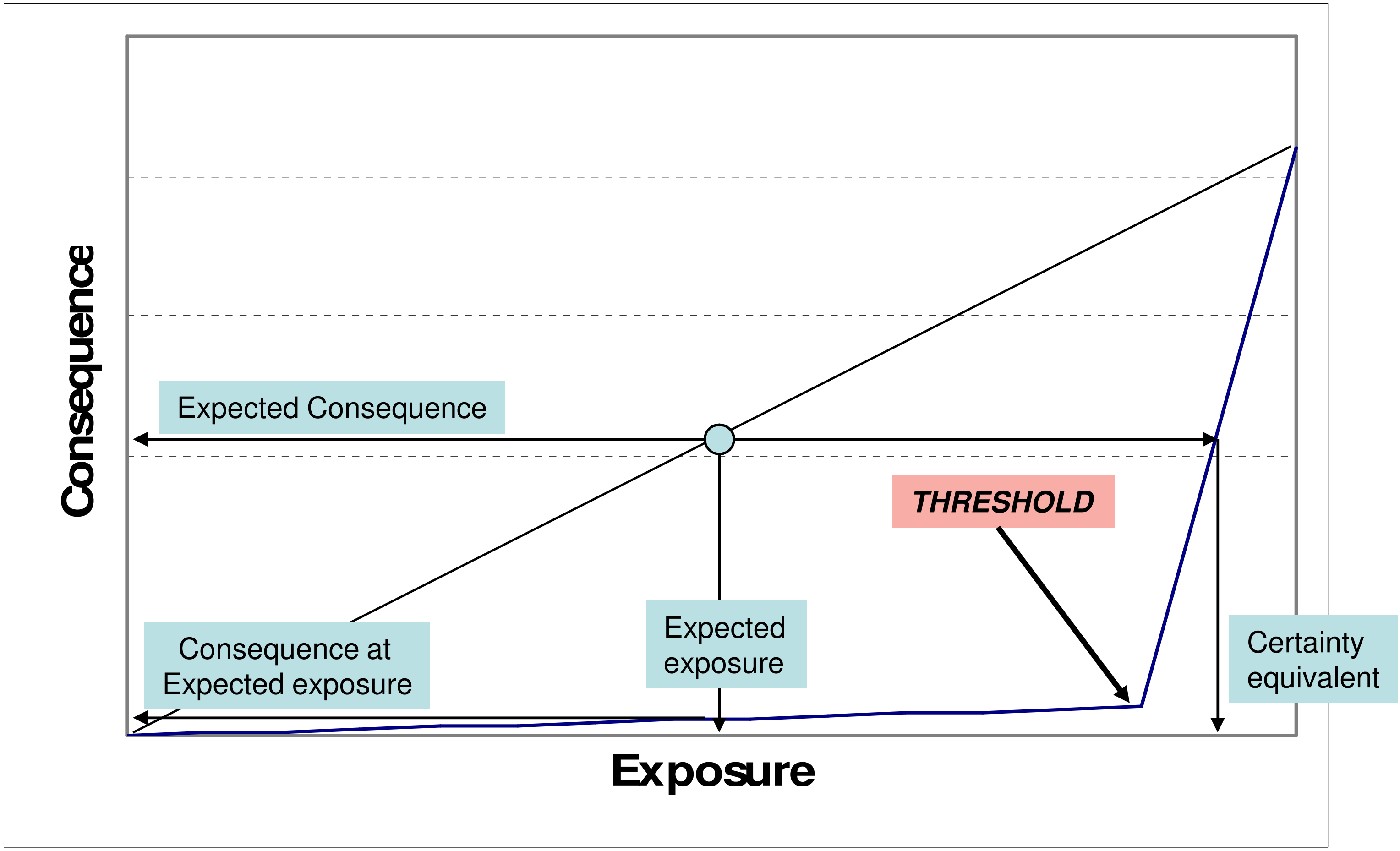
$$r = \rho + \eta g$$

- Roles:
  - Pure rate of time preference
    - (1+ρ) = MRS where consumption is equal (impatience)
  - Relative risk aversion; aversion to inequality
    - (1+πg) = MRS future to present given growth and no impatience

A Significant Complication: Lots of Stuff is Missing

	Uncertainty in Valuation →			
Uncertainty in Predicting Climate Change ↓		**Market**	**Non Market**	**(Social Contingent)**
	Projection (e.g., sea level Rise)	**I** Coastal protection; Loss of dryland; Energy (heating/cooling)	**IV** Heat stress; Loss of wetland	**VII** Regional costs; Investment
	Bounded Risks (e.g. droughts, floods, storms)	**II** Agriculture; Water; Variability (drought, flood, storms)	**V** Ecosystem change; Biodiversity; Loss of life; Secondary social effects	**VIII** Comparative advantage & market structures
	System change & surprises (e.g. major events)	**III** Above, plus; Significant loss of land and resources; Non-marginal effects	**VI** Higher order; Social effects; Regional collapse	**IX** Regional collapse

Identifying Thresholds can be Productive when Complete Analyses are not Available



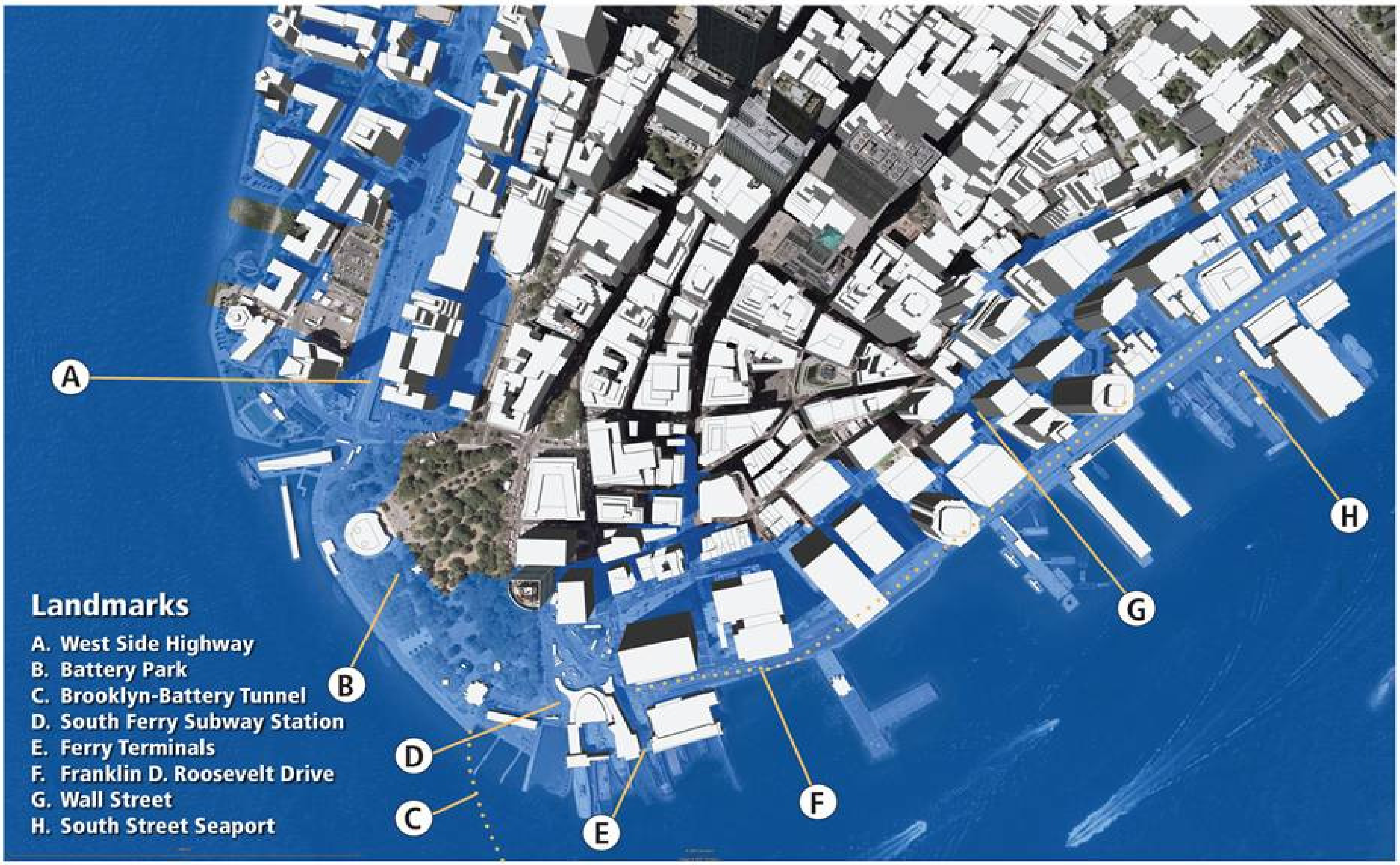
Identifying Thresholds can Simplify the Application of a Risk-Management Approach

- Estimate chances of crossing a “high consequence” threshold under alternative scenarios.
- Examples of relevant climate-related thresholds include:
  - Temperature thresholds
  - Storm event intensities and/or return-times
  - Drought
  - *Socially defined thresholds exist!*
- Key outcomes: evaluate how climate change alters the risk of a clearly definable event occurring in any given period of time regardless of how it is defined.

A "Real World" Example

- The 100-year flood in New York City:
  - It is difficult to characterize all of the consequences of the event.
  - It is possible to think rigorously about probability of this event.
  - Key questions involve how and when to invest in adaptive measures (building sea walls, enhancing pumping capacities, changing building codes).

Risk Management Example – NYC and the 100-Year Flood



www.climatechoices.org/ne/

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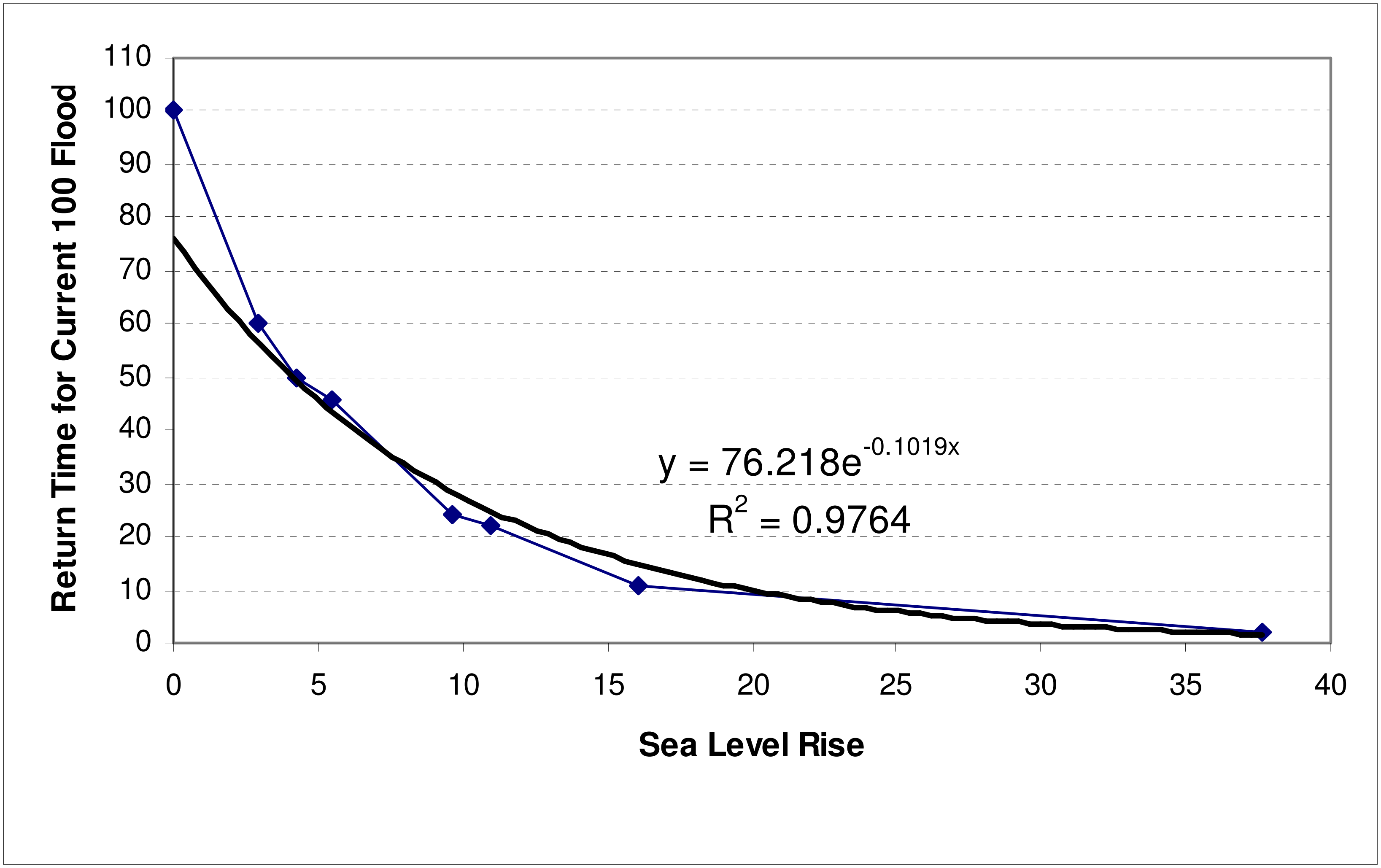

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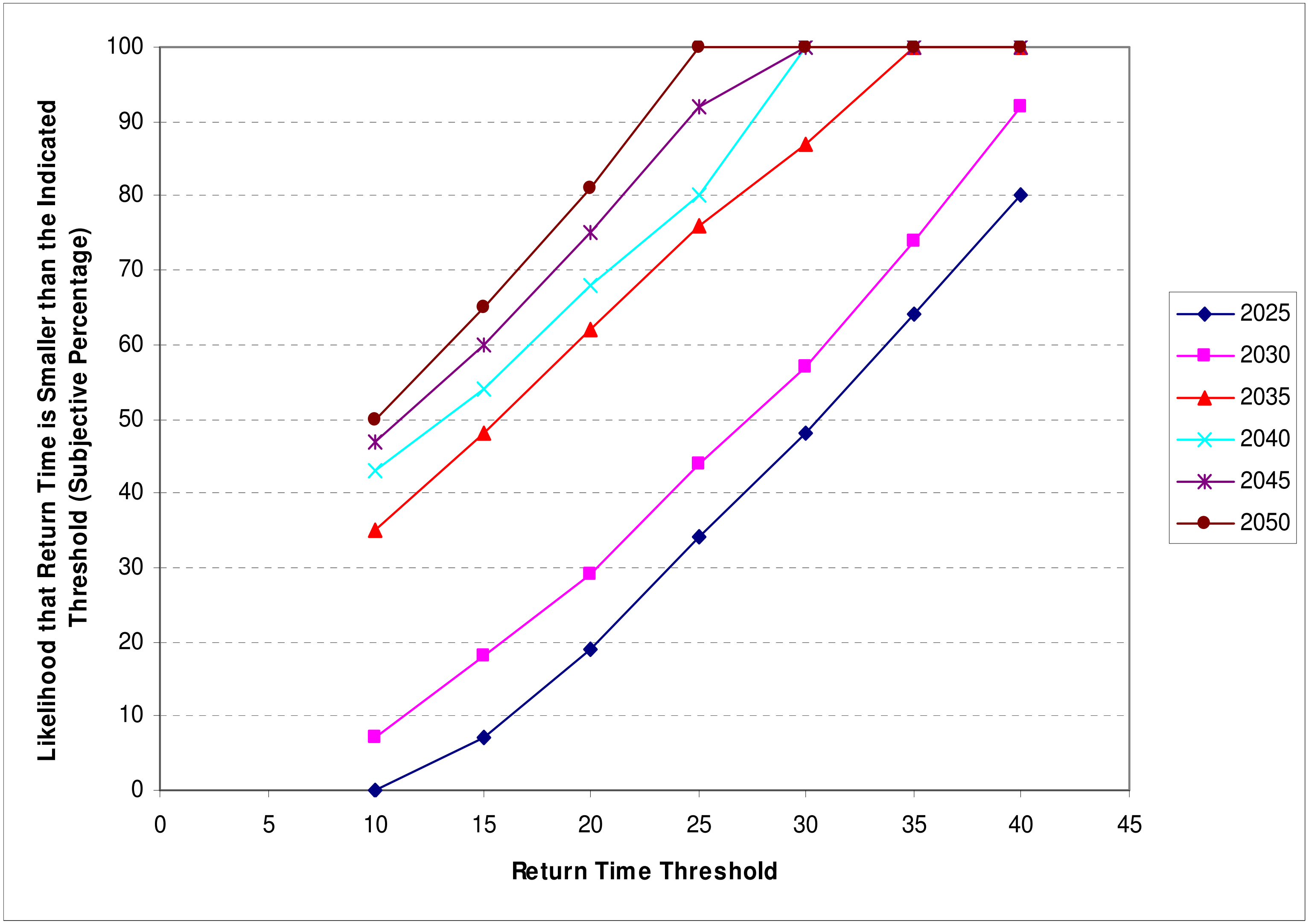
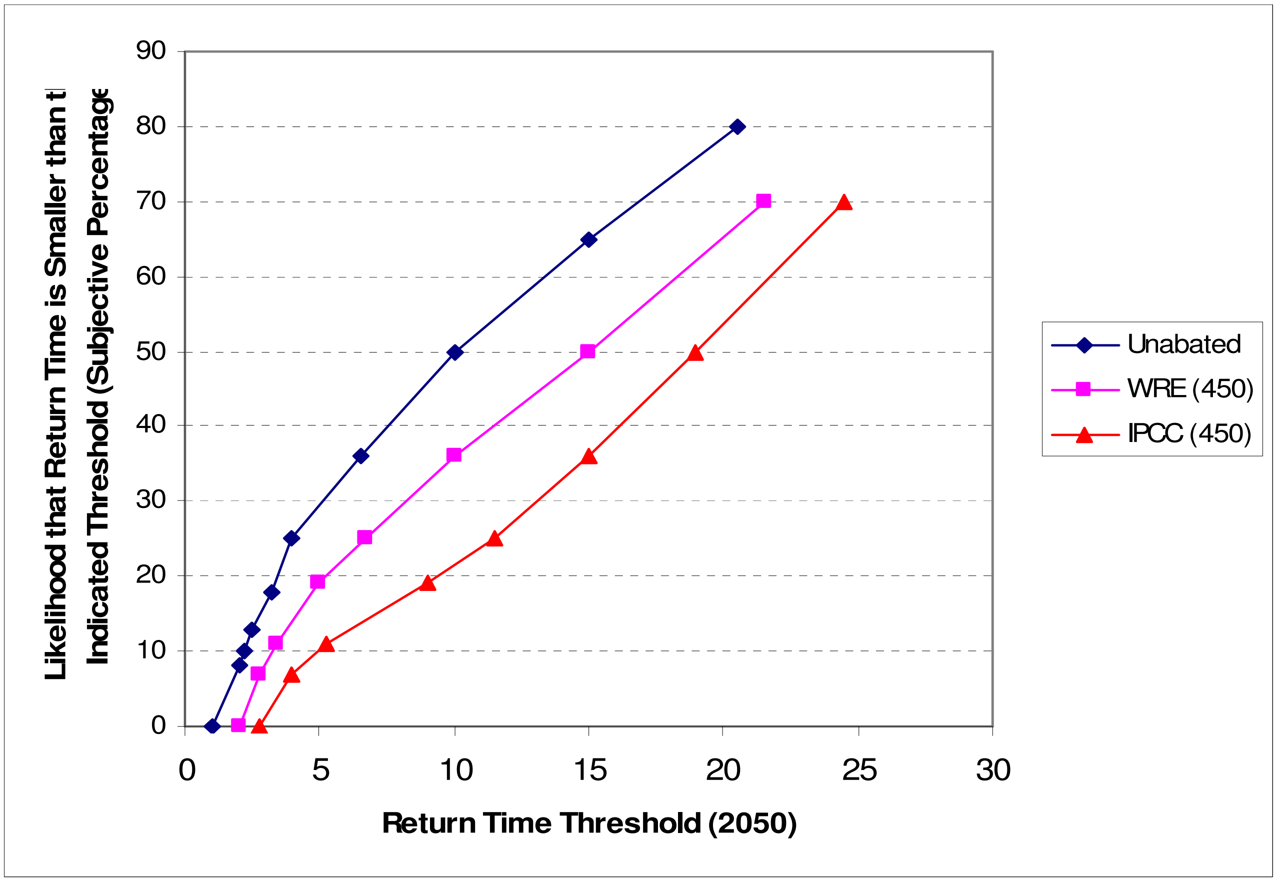


Calibration to the NYC Example: Noting the Value of Mitigation



Risk Profiles complement Benefit-Cost Calculations because they …

- can show the need for adaptation over time
- can show the need for contemplating tolerable risk levels
- can show that some significant vulnerabilities can appear in the middle of the distributions
- can show sensitivities of risk to mitigation and thereby reflect the value of mitigation and the sensitivity of this value to timing
- are unitless, so they can be compared across multiple metrics and therefore across multiple manifestations of climate change.

And so…..

Even though risk profiles can require enormous amounts of information (just like benefit-cost calculations), prioritization methods based on the statistical definition of risk and the ability to translate profiles into levels of "tolerable risk" are emerging in, for example, New York City.

I take that as encouraging news!

Thanks for your atttention