The Time Value of Carbon and Carbon Storage: Implications for Physical Carbon Discounting and GHG Accounting

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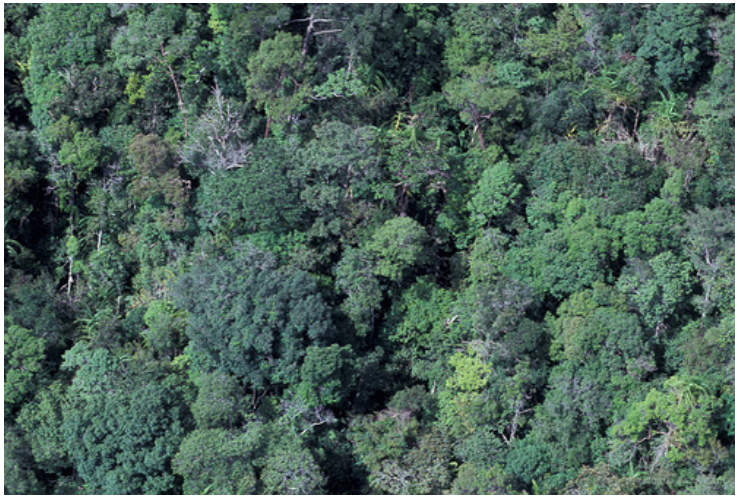
* The views expressed are the author's and should not be attributed to ERS or USDA

Temporary Storage

Is there any reason to invest in carbon mitigation projects that will capture carbon today and release an equivalent amount of carbon in 50 years?



Social Cost of Carbon

- The social cost of carbon refers to the estimate of the monetary value of world-wide damage done by anthropogenic carbon dioxide emissions (Pearce, 2002).
- total damage done, V, from the emission of one tonne of greenhouse gas (say, carbon) will be equal to the present value of all future incremental damages, since the carbon resides in the atmosphere for a long period

Factors that increase SCC	Factors that decrease SCC
High climate sensitivity	Low climate sensitivity
Low adaptive capacity	High adaptive capacity
Imperfect foresight	Perfect foresight
Coverage of abrupt change	Omission of threat of abrupt change
Enduring damages	Short-lived damages
High value of life	Low value of life
High ecosystem value	Low ecosystem value
Comprehensive impacts	Limited impact coverage
Indirect & direct cost	Accounting for direct costs only
High geographic detail	Limited geographic detail

Adapted from SEI (2005)

SCC carbon figures ($/Ton CO_2)

Discount	5%	3%	2.5%
Year	Average	Average	Average
2010	4.7	21.4	35.1
2015	5.7	23.8	38.4
2020	6.8	26.3	41.7
2025	8.2	29.6	45.9
2030	9.7	32.8	50.0
2035	11.2	36.0	54.2
2040	12.7	39.2	58.4
2045	14.2	42.1	61.7
2050	15.7	44.9	65.0

NPV of SCC figures ($/Ton CO_2)

Discount	5%	3%	2.50%
Year	Average	Average	Average
2010	4.7	21.4	35.1
2015	4.4661	20.5301	33.94
2020	4.17461	19.5697	32.576
2025	3.94434	18.9991	31.6924
2030	3.65583	18.1606	30.5135
2035	3.30739	17.1938	29.235
2040	2.93849	16.1499	27.8418
2045	2.57432	14.9616	25.9986
2050	2.23012	13.7644	24.208

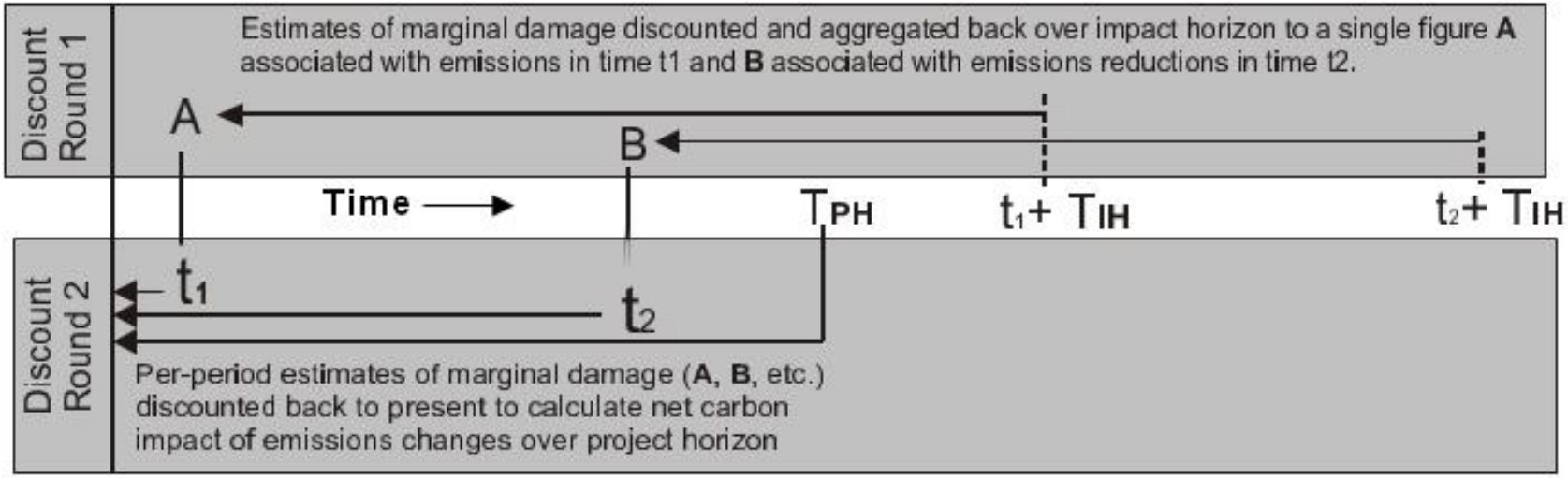
“All models are wrong, but some are useful.”

–George Box

Key Questions for Biofuels GHG Accounting

- What is the conceptual relationship between SCC and physical carbon discount rates?
- What are the implications of the recently released SCC numbers for estimation of physical carbon discount rates?
- How do we accommodate the uncertainty associated with the set of estimated outcomes in policy design?
- What are the implications of the weaknesses in the SCC estimation for physical carbon discounting?

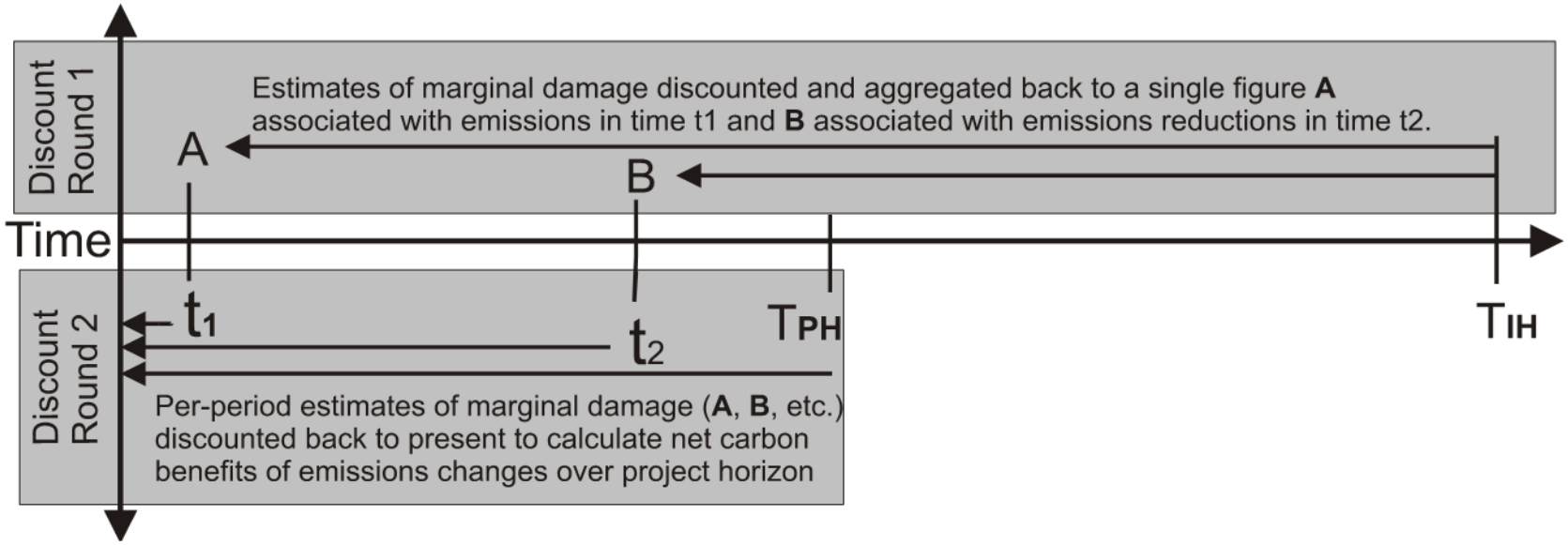
Relevant Time Horizons for Biofuels Analysis



Impact Horizon: The period of time over which warming impacts from a unit of emissions are measured

Project Horizon: The period of time over which a project or regulation results in changes of emissions or emissions timing

Truncated Impact Horizon



- Builds a bias into the SCC calculation because impacts of emissions are measured over different time horizons.

Biofuels: Carbon discounting

- SCC numbers can be used to derive "equivalent" carbon discounting figures that re-create paths of relative damages from emissions over time.

	SCC figure for 2.5% discount rate scenario ($/Ton CO2)	NPV of SCC, discounted to present using a 2.5% discount rate ($/Ton CO2)	Weight of Damages Relative to year 2010	Physical Discount Rate
2010	35.1	35.10	1.0000	0
2015	38.4	33.94	0.9670	0.006744
2020	41.7	32.58	0.9281	0.007491
2025	45.9	31.69	0.9029	0.006832
2030	50	30.51	0.8693	0.007026
2035	54.2	29.23	0.8329	0.00734
2040	58.4	27.84	0.7932	0.007752
2045	61.7	26.00	0.7407	0.008613
2050	65	24.21	0.6897	0.009331

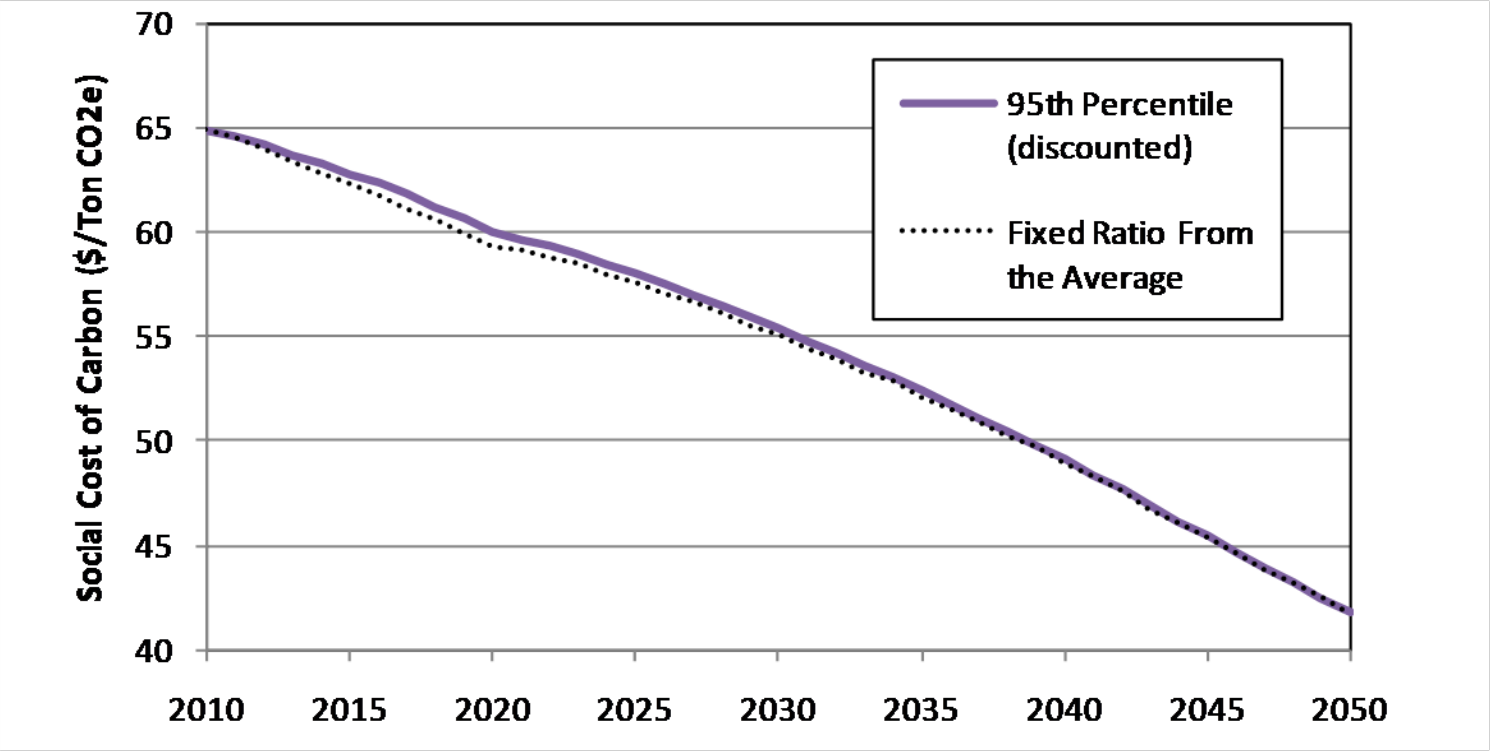
Accommodating Uncertainty

- Use of a non-central estimator is often considered a more conservative estimate that will more effectively capture the uncertainty associated with such outcome distributions.
- Value of temporary storage depends on differences between values of SCC over time.
- But physical carbon discounting is a measure of relative weight, and therefore based on ratios of SCC values over time.
- If in the estimated distribution the ratios stay exactly the same, then there will be no change in the SCC-equivalent physical carbon discount rate

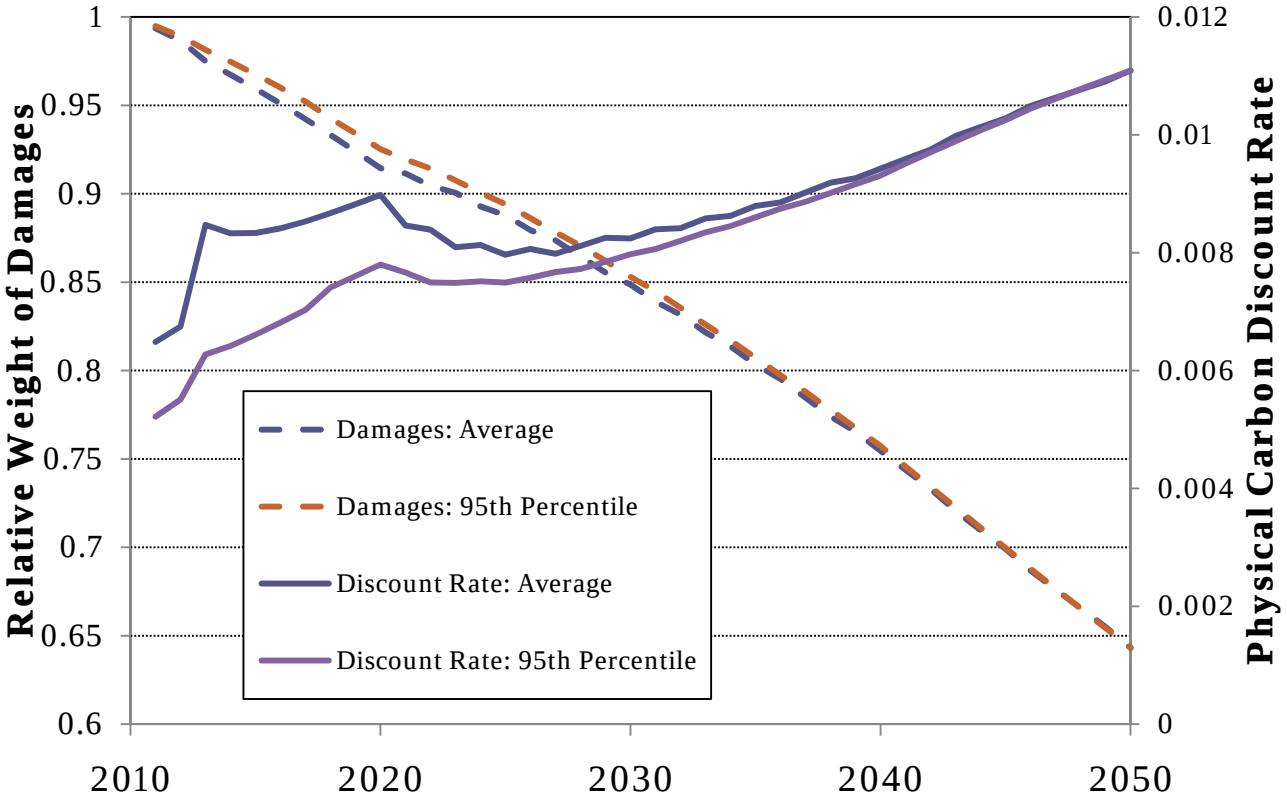
Distribution Profile

Discount	3%	3%	3%
year	Avg. ($/Ton CO_2)	95th percentile ($/ Ton CO_2)	Ratio of 95th to Average
2010	21.4	64.9	3.0
2015	23.8	72.8	3.1
2020	26.3	80.7	3.1
2025	29.6	90.4	3.1
2030	32.8	100	3.0
2035	36	109.7	3.0
2040	39.2	119.3	3.0
2045	42.1	127.8	3.0
2050	44.9	136.2	3.0

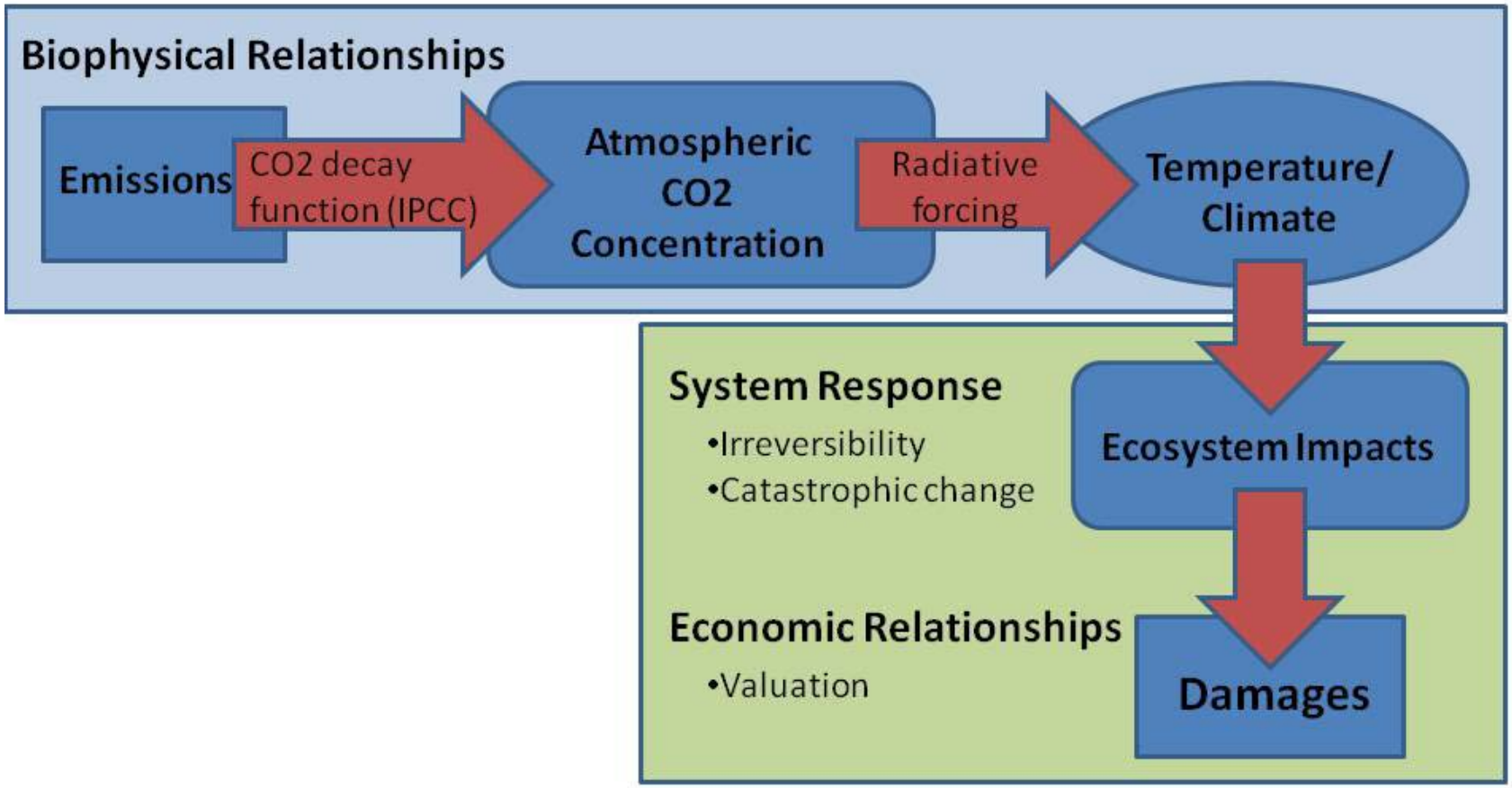
Distribution Profile



Implications for Physical Carbon Discount Rate



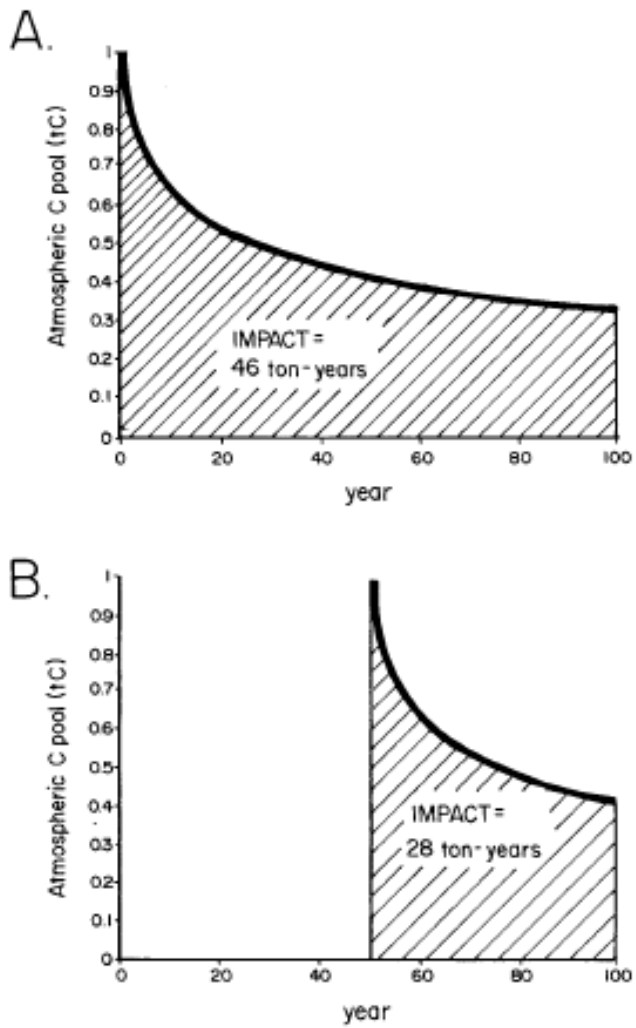
Sources of Uncertainty



Calculating PDR from Carbon Accumulation

- If the carbon decay function is not a function of atmospheric concentration or temperature, then every unit emission over time will decay in exactly the same way.
- Cumulative “carbon impact” doesn’t change with emission time period
- The only thing that causes a time effect that could be used to calculate a PDR is truncation of the impact horizon, as illustrated by the ton-year approach.

Ton-year discounting



- Time effect used to generate discount rate arises purely through the truncation effect

	Ton-years	Relative Weights	Physical Discount Rate
2010	48.88	1.0000	0.00000
2015	47.05	0.9627	0.00763
2020	45.20	0.9249	0.00784
2025	43.33	0.8866	0.00806
2030	41.43	0.8477	0.00830
2035	39.50	0.8082	0.00855
2040	37.54	0.7681	0.00883
2045	35.55	0.7273	0.00914
2050	33.52	0.6857	0.00948

Radiative Forcing

•A time effect arises due to exogenous changes in CO2 concentrations, which affect the radiative efficiency of emissions; forcing declines with increasing concentrations.

	Cumulative Radiative Forcing		Relative Weight		Physical Discount Rate	
	Truncated	Non-truncated	Truncated	Non-truncated	Truncated	Non-Truncated
2010	0.5188	0.5188	1.0000	1.0000	0.00000	0.00000
2015	0.4892	0.5033	0.9429	0.9701	0.01182	0.00609
2020	0.4606	0.4887	0.8878	0.9420	0.01197	0.00600
2025	0.4329	0.4749	0.8346	0.9154	0.01213	0.00591
2030	0.4061	0.4619	0.7829	0.8904	0.01231	0.00582
2035	0.3801	0.4496	0.7327	0.8667	0.01252	0.00574
2040	0.3547	0.4380	0.6838	0.8443	0.01275	0.00566
2045	0.3299	0.4270	0.6360	0.8231	0.01301	0.00558
2050	0.3057	0.4165	0.5892	0.8029	0.01331	0.00550