Costs Borne by Society for Energy

CBS_t	=	$(CO_2e_t \times SCC_t)$	+	$(kWh_t \times SCNC_t)$

- **Carbon emissions**
  - CO_2
  - CO
  - CH_4
- **Non-carbon emissions**
  - SO_2
  - NO_x
  - Particulates

- **TOTAL = sum over years t**

$$VI1997 = \sum t\uparrow\blacksquare CBS\downarrow t /(1+DR)\uparrow t - 1997$$

DR = discount rate

Energy Nexus of Remedial Systems

CBS_t	=	$(CO_2e_t \times SCC_t)$	+	$(kWh_t \times SCNC_t)$

Environmental Metric	Societal Dis-Amenities
Carbon Dioxide (CO_2,)	Long-term global impacts of climate change, including changes in net agricultural productivity, human health, property damages from increased flood risk, and the value of ecosystem services (USG 2013).
Energy (non-carbon social cost)	Long-term societal impacts, including health costs, shortened life spans, environmental mitigation, and broad impacts of climate change (Greenstone et al. 2011)

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How To Choose a Social Cost of Carbon Value?

CBS_t	=	$(CO_2e_t \times SCC_t)$	+	$(kWh_t \times SCNC_t)$

How To Choose a Social Cost of Carbon Value?

Revised Social Cost of CO_2, 2010 – 2050 (in 2007 dollars per metric ton of CO_2)

Discount Rate	5.0%	3.0%	2.5%	3.0%
Year	Avg	Avg	Avg	95th
2010	11	33	52	90
2015	12	38	58	109
2020	12	43	65	129
2025	14	48	70	144
2030	16	52	76	159
2035	19	57	81	176
2040	21	62	87	192
2045	24	66	92	206
2050	27	71	98	221

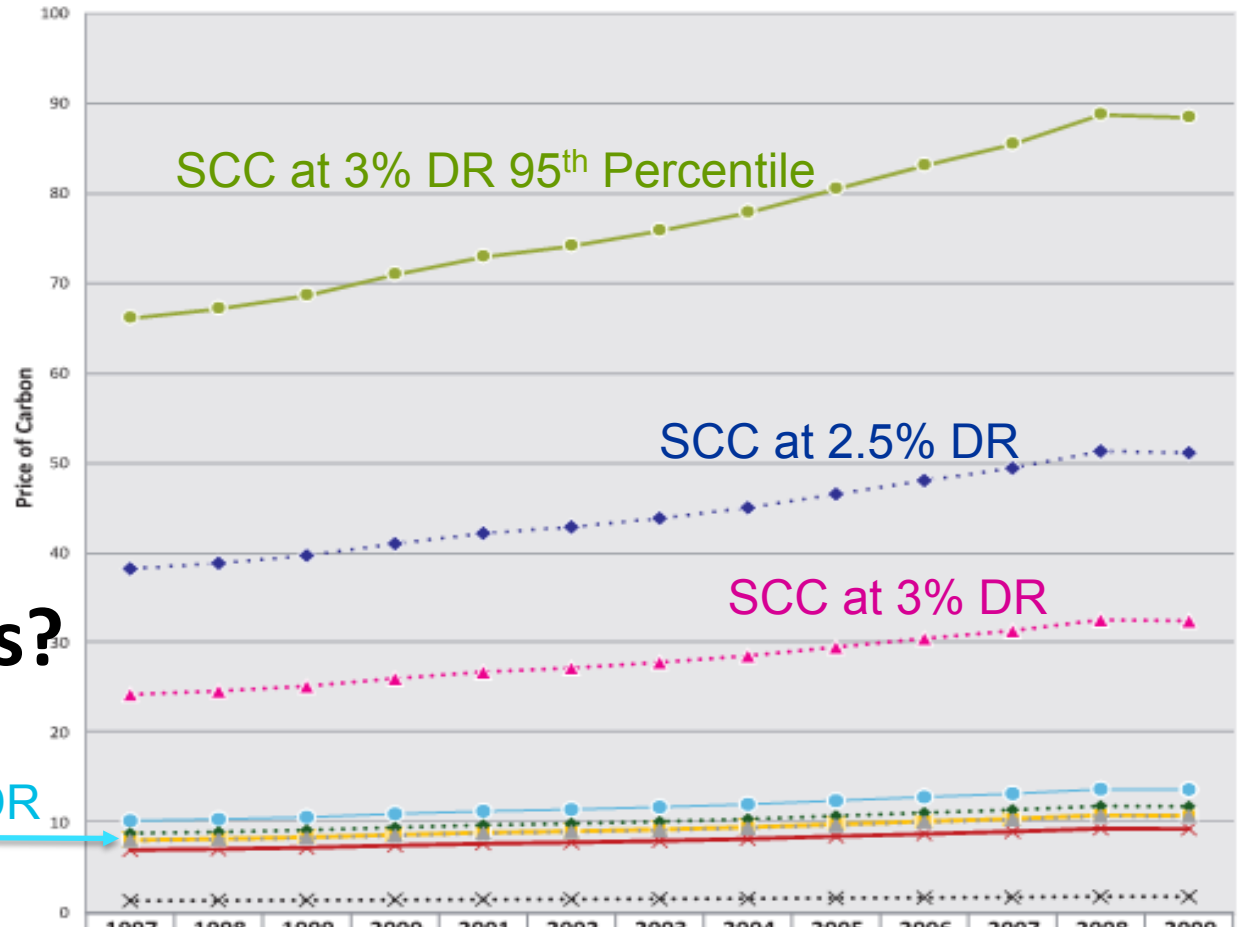
Source: *Technical Support Document – Technical Update of the Social Cost of Carbon for Regulatory Impact Analysis. Interagency Working Group on Social Cost of Carbon, United States Government, May 2013.*

How To Choose a Social Cost of Carbon Value?

- A lower discount rate means society places more weight on future impacts
  - (e.g., climate change and chronic human health impacts).

- A higher discount rate means society places more weight on present impacts
  - (e.g., daily congestion and inconvenience due to remedial activities taking place)

How Does Discount Rate Relate to Market Values?



	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
CA GHG Cap-&-Trade (metric ton)	6.99	7.10	7.26	7.50	7.71	7.84	8.01	8.23	8.51	8.78	9.03	9.38	9.34
Regional GHG Initiative (RGGI) (metric ton)	1.35	1.37	1.40	1.45	1.49	1.51	1.55	1.59	1.64	1.69	1.74	1.81	1.88
Quebec's Carbon Market (metric ton)	6.99	7.10	7.26	7.50	7.71	7.84	8.01	8.23	8.51	8.78	9.03	9.38	9.34
USG Social Cost - 5.0% Discount Avg. Yr. (metric ton)	8.10	8.22	8.40	8.69	8.93	9.08	9.28	9.53	9.85	10.17	10.46	10.86	10.82
USG Social Cost - 3.0% Discount Avg. Yr. (metric ton)	24.29	24.67	25.21	26.06	26.79	27.23	27.85	28.59	29.56	30.51	31.38	32.58	32.47
USG Social Cost - 2.5% Discount Avg. Yr. (metric ton)	38.27	38.87	39.73	41.06	42.21	42.90	43.88	45.05	46.57	48.08	49.45	51.34	51.16
USG Social Cost - 3.0% Discount 95th Percentile Year	66.24	67.28	68.76	71.07	73.05	74.25	75.94	77.97	80.61	83.21	85.58	88.86	88.55
Synapse High Bound Price Forecast (short ton)	10.25	10.41	10.64	11.00	11.31	11.49	11.76	12.07	12.48	12.88	13.25	13.76	13.71
Synapse Mid Bound Price Forecast (short ton)	8.86	9.00	9.20	9.51	9.77	9.93	10.16	10.43	10.78	11.13	11.45	11.89	11.84
Synapse Low Bound Price Forecast (short ton)	8.03	8.16	8.34	8.62	8.86	9.00	9.21	9.45	9.77	10.09	10.38	10.78	10.74

Year

Costs Borne by Society

For CO_2e:

Year	Damages		Damages		Market Price C	
	P&T 2.5% DR	Bio 2.5% DR	P&T 5% DR	Bio 5% DR	P&T Average	Bio Average
1997	$2,061	$2,061	$436	$436	$315	$315
1998	$4,133	$4,133	$853	$853	$631	$631
1999	$3,513	$3,513	$707	$707	$536	$536
2000	$1,667	$1,667	$328	$328	$255	$255
2001	$1,708	$1,708	$328	$328	$261	$261
2002	$1,693	$1,693	$317	$317	$259	$259
2003	$958	$958	$175	$175	$146	$146
2004	$2,242	$1,095	$400	$195	$342	$167
2005	$2,261	$1,065	$394	$185	$345	$163
2006	$2,277	$1,291	$262	$219	$348	$197
2007	$2,285	$1,161	$257	$193	$349	$177
2008	$2,315	$647	$375	$105	$353	$99
2009	$2,250	$270	$356	$42	$343	$41
TOTAL	***$29,369***	***$21,267***	***$5,195***	***$4,089.53***	**$4,483**	**$3,247**

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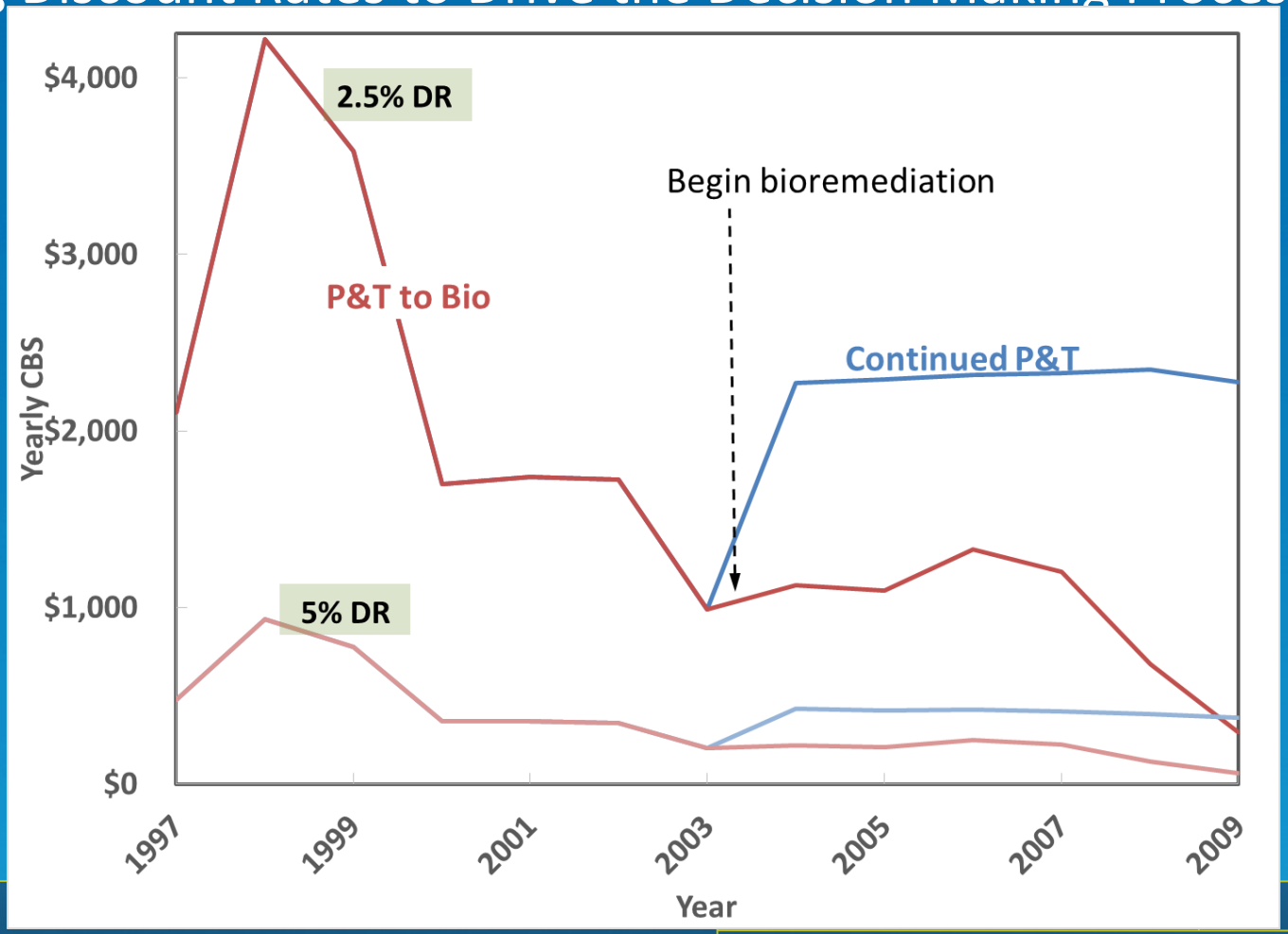
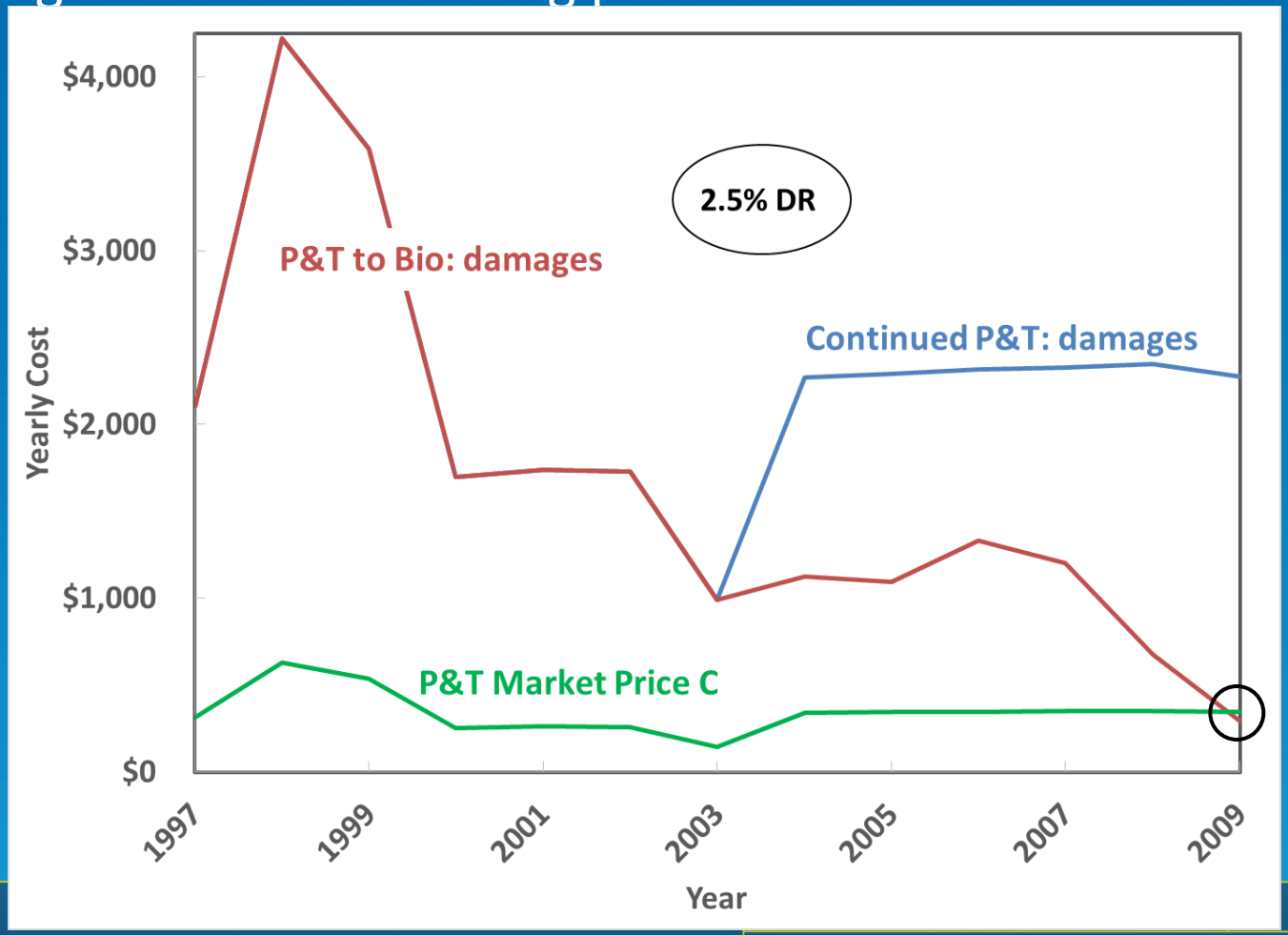
Costs Borne by Society of CO_2e

- Using Discount Rates to Drive the Decision Making Process



Calculated Costs of CO_2e

- Damages vs. carbon trading price

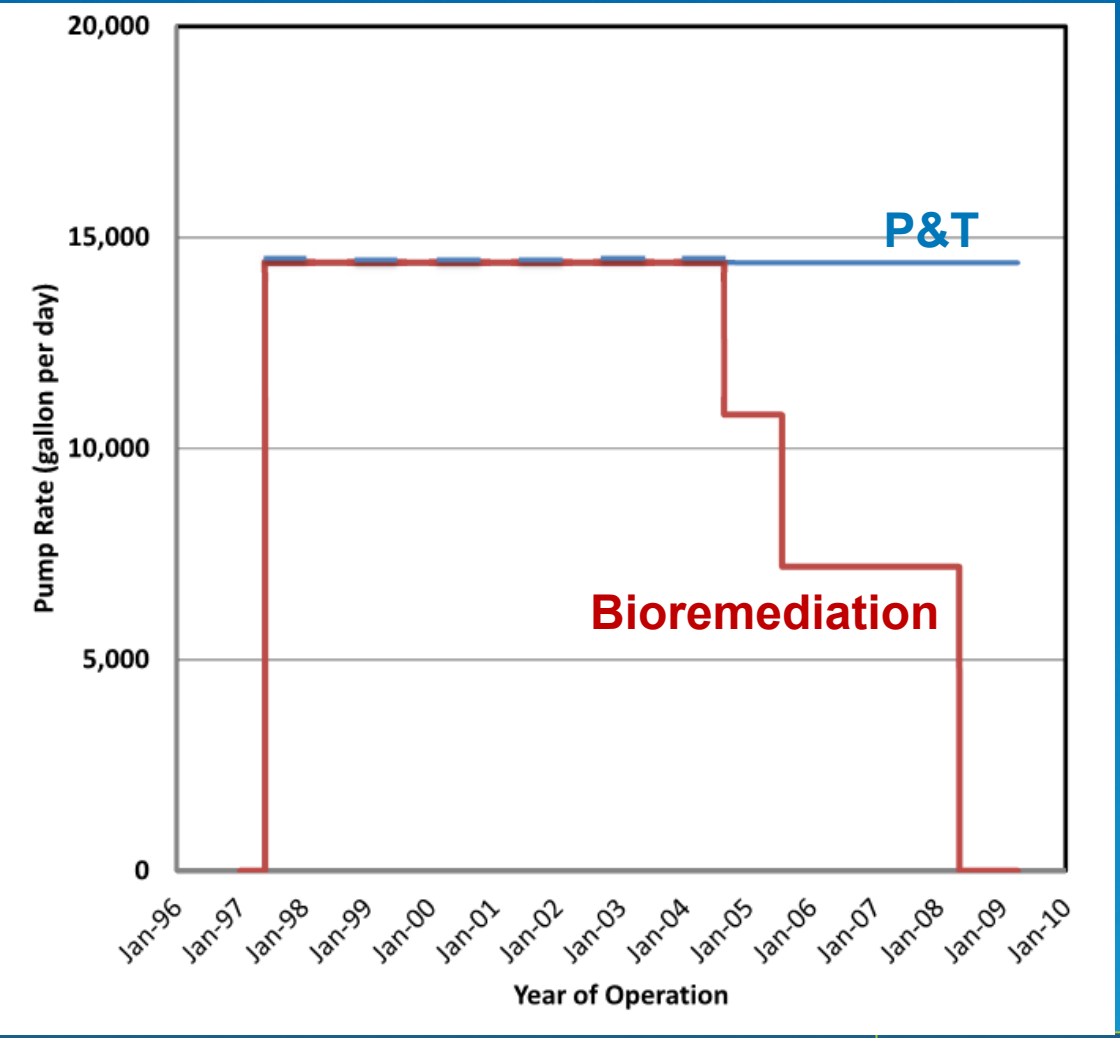


Costs Borne by Society: Results

- Lower discount rate → estimate long-term impacts
- 13 years of operation
  - Continued P&T: CBS = $30,000
  - P&T transition to bio: CBS = $22,000
- CO_2e damages ≥ carbon trading price

- **Decision Point for comparison of remedial alternatives: Lowest CBS**

Water Footprint



- Social cost of water consumption?
  - Limited data
  - Much spatial variability

Conclusions

- Monetization of impacts: universally recognized unit
- Normalization of disparate elements
- Lower discount rate to capture long-term effects
- Quantify social and economic implications of GR
- Bridge to SR without compromising cleanup

Broader Implications: Monetization of Impacts

- Convince skeptics of benefits
  - Green remediation
  - (and sustainable remediation)
- Mechanism to "sell" climate change adaptation of remedial systems
- Gateway to sustainable remediation/risk management

Questions and Answers

Harclerode, M. A., P. Lal, and M. E. Miller. 2015. *Quantifying Global Impacts to Society from the Consumption of Natural Resources during Environmental Remediation Activities*. Journal of Industrial Ecology, Special Issue: Linking Local Consumption to Global Impacts.

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