PRESENTATION TO DOMESTIC POLICY COUNCIL WORKING GROUP

Prepared by

COUNCIL OF ECONOMIC ADVISERS

and

DPC WORKING GROUP SUBCOMMITTEE ON BENEFITS AND COSTS

Friday, June 5, 1987

ADVERSE EFFECTS OF STRATOSPHERIC OZONE DEPLETION EXAMINED (U.S. ONLY)

- Fatal skin cancers
- Non-fatal skin cancers
- Cataracts
- Crops, fish, and shellfish
- Ground level ozone
- Sea level rise

EFFECTS NOT EXAMINED

- Human immune system
- Climate change

SOURCES OF ECONOMIC UNCERTAINTY

- Valuation of life and health effects
- Discount rate issues
- Time profiles of effects
- Cost estimates
- Uncertainties in non-health economic benefit estimates

VALUATION OF LIFE AND HEALTH EFFECTS

- "Value of life" is shorthand for people's willingness to pay (WTP) to avoid risks.
- Estimates are based on:
  - Wage premiums for risky jobs.
  - Direct payments to avoid risks.
  - Variations in property values.
- Estimates are <u>not</u> based on:
  - Court awards in wrongful death cases.
  - Present values of lifetime earnings.
- "Willingness to pay" to avoid risks increases with wealth and income. But:
  - Should "value of life" of future generations be increased to reflect economic growth? If so, at what rate?
- No adjustment made for possible different WTP for people of different ages.
  - Older people have fewer years to live -- lower WTP.
  - Older people are wealthier -- higher WTP.
  - No empirical evidence that older people are more willing to bear risks than younger people.
- WTP estimates in the literature vary; Subcommittee recommendation: Report $2,000,000 and $4,000,000.

SUMMARY OF MARKET STUDIES OF RISK TRADEOFFS

Investigator	Sample	Implicit Value of Life (millions of 1982 dollars)
Blomquist (1979)	Seatbelt usage, panel study of income dynamics, 1972	$.56
Brown (1980)	National longitudinal survey, 1967-1973	$1-$1.5
Leigh (forthcoming)	Panel study of income dynamics, 1974	$3.8-$8.9
	Quality of employment survey, 1977	$4.8-$8.4
Olson (1981)	Current population survey, 1973	$7.4
Portney (1981)	Air pollution and property values	$.593-$.890
Smith (1985)	Current population survey, 1967	$7.5
	Current population survey, 1973	$3.3
Thaler & Rosen (1976)	Survey of economic opportunity	$.500
Viscusi (1979)	Survey of working conditions, 1970-1	$2.9-$3.9
Viscusi (1981)	Panel study of income dynamics, 1976	$7-$11

Source: W. Kip Viscusi, "The Valuation of Risks to Life and Health: Guidelines for Policy Analysis," in J.D. Bentkover et al (eds.), Benefits Assessment: The State of the Art, D. Reidal Publishing Company, 1986, pg. 201

DISCOUNT RATE ISSUES

- Costs and benefits should be discounted by real rate of interest.
  - Rate of return on all assets (including housing), pre-tax.
  - Rate at which present consumption can be transformed into future consumption.
  - Rate which future generations would use in making investment decisions if they could.
  - No strong consensus on what the economy-wide real rate of return is.
  - Subcommittee recommendation: Report 4% and 6%.
- What type of investment is a CFC control policy?
  - Some assets earn a higher rate of return than the economy-wide average; some a lower.
  - People will accept lower rate of return on an insurance policy against a very bad outcome: life insurance, strategic petroleum reserve.
  - Scientific uncertainties suggest no action on CFCs may have severe adverse consequences.
- Should a discount rate <u>higher</u> or <u>lower</u> than the real rate of interest be used?
  - Present generation may value future generations more or less than itself.
  - This is an ethical question, not an economic one.

IMPLICATIONS OF USING A DISCOUNT RATE HIGHER THAN THE REAL RATE OF INTEREST

EXAMPLE:

Real interest rate = 5%

Discount rate = 10%

Compensate for normal per capita income growth so that $1.82 of real income to the next generation yields the same utility as $1.00 for the present generation.

30 years between generations.

RELATIVE WEIGHTS ASSIGNED TO WELFARE

Current generation: 1

Next generation: .41

Second generation: .17

EPA ESTIMATES OF
SHORT-TERM COSTS OF CFC CONTROLS

Case	Undiscounted Cumulative Costs 1990-2000 (billions)
Protocol Freeze	$0.623
Freeze + 20% cut	$1.95
Freeze + 50% cut	$5.50

TOTAL COSTS OF CFC CONTROLS TO THE ECONOMY

2 Cases:

- Marginal costs grow at .625% per year forever.
- Marginal costs grow at 2.5% per year forever.

Total Discounted Present Value of Marginal Costs (billions of dollars)

Step	Discount Rate 4%	6%
(No action) to (Freeze)	$1.6 - $3.3	$1.0 - $1.4
(Freeze) to (Freeze + 20%)	$3.5 - $7.0	$2.2 - $3.0
(Freeze + 20%) to (Freeze + 50%)	$9.2 - $18.7	$5.8 - $8.0
(No action) to (Freeze + 20%)	$5.1 - $10.3	$3.2 - $4.4

BENEFITS FROM AVERTING SKIN CANCER DEATHS,
COHORTS BORN BEFORE 2075

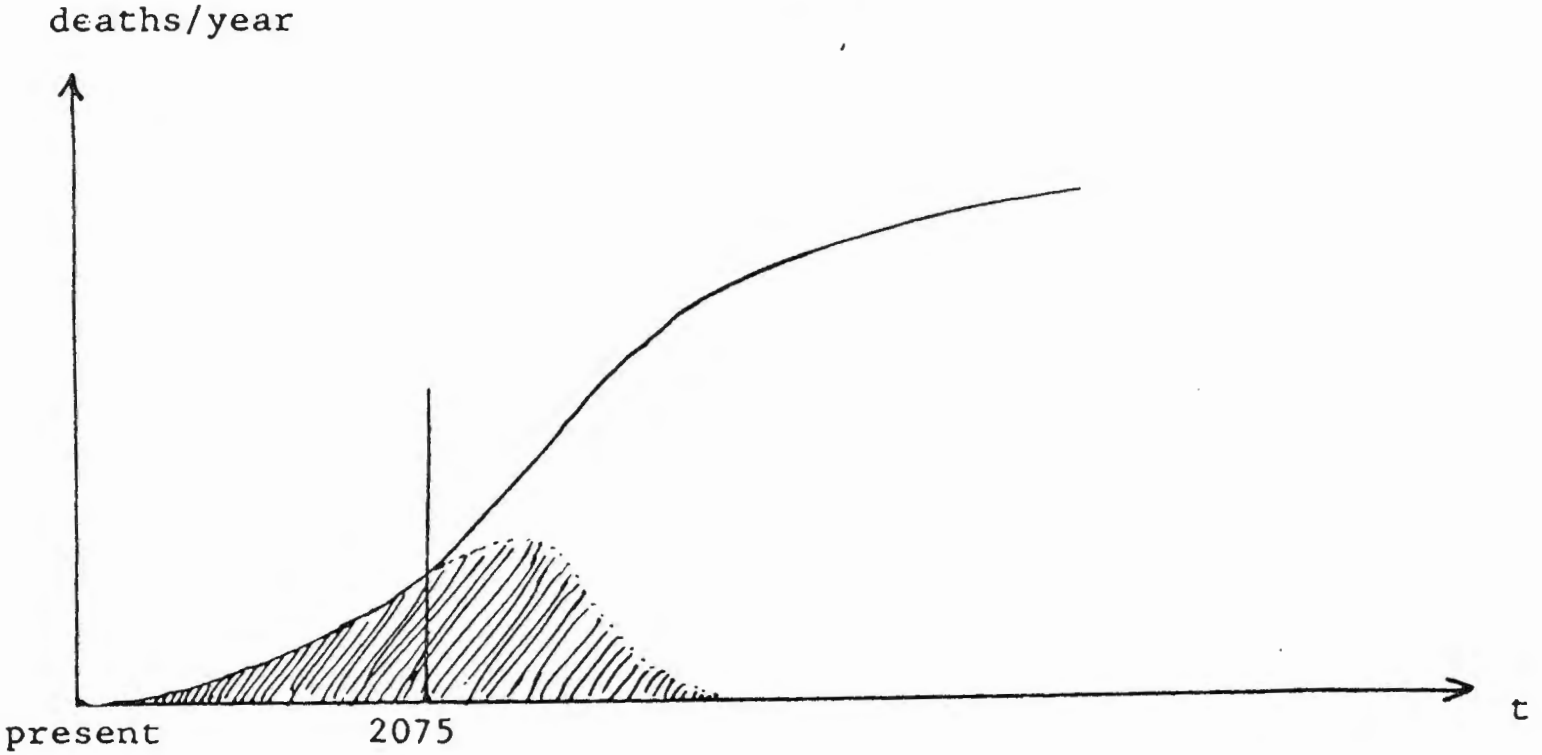
(#'s cld be d'd as much as 2/3)

Action	Deaths Averted
Protocol Freeze	947,000
Freeze + 20% cut	993,000
Freeze + 50% cut	1,072,000

Step	Marginal Deaths Averted
(No Action) to (Protocol Freeze)	947,000
(Freeze) to (Freeze + 20% cut)	46,000
(Freeze + 20% cut) to (Freeze + 50% cut)	79,000

- Protocol Freeze not a true global freeze; standard scenario assumptions for freeze and cuts.
- EPA central case estimates of deaths averted.

TIME PROFILE OF DEATHS AVERTED



- Shaded area = deaths averted in cohorts born before 2075.
- Death rate continues to rise after 2075 because the stratosphere is not in equilibrium by 2075 and ozone depletion is continuing.
- Total area under curve equals total deaths averted by control action.
- Exact size, shape, and location of curve is not known.
- Sensitivity analysis attempts to show limits of that uncertainty.

EXAMPLE 1

Assumptions:

- Value of statistical life = $2,000,000.
- Value of life grows over time at historical rate of per capita GNP growth, 2% per year.
- Average of 4 time profiles, with "standard errors" (in parentheses) calculated to give an indication of time profile uncertainty.

MARGINAL BENEFITS (billions of dollars)

Step	Discount Rate 4%	6%
(No Action) to (Freeze)	$ 482 (± 161)	86 (± 46)
(Freeze) to (Freeze + 20%)	22 (± 4.0)	4.3 (± 2.2)
(Freeze + 20%) to (Freeze + 50%)	38 (± 7.8)	7.1 (± 3.6)
(No Action) to (Freeze + 20%)	$ 504 (± 164)	90 (± 49)

EXAMPLE 2

ASSUMPTIONS:

- Value of statistical life = $2,000,000.
- Value of life constant over time.
- Average of 4 time profiles (standard errors in parentheses).

MARGINAL BENEFITS (billions of dollars)

Step	Discount Rate 4%		6%	
(No Action) to (Freeze)	$ 94	(± 50)	22	(± 19)
(Freeze) to (Freeze + 20%)	4.6	(± 2.2)	1.2	(± .9)
(Freeze to 20%) to (Freeze + 50%)	7.6	(± 3.7)	2.0	(± 1.6)
(No Action) to (Freeze +20%)	$ 99	(± 52)	23	(± 20)

EXAMPLE 3

Assumptions:

- Value of statistical life = $4,000,000.
- Value of life grows over time at historical rate of per capita GNP growth, 2% per year.
- Average of 4 time profiles, standard errors in parentheses

MARGINAL BENEFITS (billions of dollars)

Step	Discount Rate 4%		6%	
(No Action) to (Freeze)	$964	(± 322)	172	(± 92)
(Freeze) to (Freeze + 20%)	44	(± 8.0)	8.6	(± 4.4)
(Freeze + 20%) to (Freeze + 50%)	76	(± 16)	14	(± 7.2)
(No Action) to (Freeze + 20%)	$1008	(± 328)	180	(± 98)

NON-FATAL SKIN CANCERS

Information Required:

- Numbers and time profiles, non-melanomas and melanomas
- Distribution of seriousness
  - Non-melanomas
  - Melanoma
- Valuation of non-fatal cases

Illustrative Example:

Non-melanomas			Melanomas	
Type	%	Value	Type	Value
Very Serious	10%	$60,000	Non-fatal	$60,000
Serious	15%	5,000		
Not so serious	25%	1,000		
Least serious	50%	100		

- Total benefits in this example are on the order of 13% of benefits from averting deaths.

CATARACTS

Information Required:

- Numbers and time profiles
- Valuation
  - Medical expenses
  - Pain and suffering
  - Restricted activities

Illustrative Example:

- With value of cataract case at $16,000, cataract benefits are at least an order of magnitude less than the benefits from skin cancer deaths averted.

CROPS, FISH, SHELLFISH

- Effects are difficult to quantify because:
  - Effects on yields of full range of crops not known.
  - Relative growth of these components of GNP not known.
  - Price effects not known.
- For the U.S., effects are probably small relative to health effects.

GROUND-LEVEL OZONE

- Effects include health and crop impacts.
- Preliminary work in progress suggests these effects are small relative to UVB-related health impacts.

SEA LEVEL RISE

- EPA quantification includes only cities, not entire shoreline.

- Marginal impacts of CFC controls on projected sea level rise are small relative to potential global warming effects.

EPA 6/8

SUMMARY OF HEALTH AND ENVIRONMENTAL EFFECTS

Depletion of the ozone layer would result in increased penetration of biologically damaging ultraviolet radiation (UV-B) to the earth's surface. Based on the research completed to date, greater exposure to UV-B radiation has been linked to increases in the number of skin cancers and cataracts, suppression of the human immune response system, damage to crops and aquatic organisms, increased formation of ground-level ozone (smog), and accelerated degradation of certain plastics.

Based on case control, epidemiological, and ecological studies, dose-response relationships were developed and reviewed as part of EPA's risk assessment. In the absence of any limits on CFC use, projected ozone depletion would lead to approximately 1.2 million additional skin cancer deaths among populations born before 2075. This analysis also suggests that a protocol freeze of CFC-11, -12, and -113 could result in almost 950,000 fewer deaths in the U.S. for populations born before 2075. A 50 percent reduction in the major CFCs would result in almost 1.1 million fewer skin cancer deaths. This analysis assumes that current trends toward increased exposure to sunlight are halted, that the average age of the population remains constant, and that no major improvements in treatment of skin cancer occur.

Recent studies have also shown a strong dose-response relationship beteen UV-B and the incidence of cataracts. Approximately 12.5 million cases in the U.S. could be averted by a protocol freeze for cohorts born by 2075. A 50% reduction in the major CFCs would result in approximately 15 million cases averted. While laboratory studies link UV-B to suppression of the human response system with possible implications for increasing the incidence of herpes simplex and leishmaniasis, research into possible broader implications has not been undertaken.

Limited studies have examined the effects of increased UV-B radiation on plants and aquatic organisms. Five years of field studies of soy beans provide the most extensive data and suggest potentially large losses in yield. Laboratory studies of UV-B effects on aquatic organisms show changes in community composition and reduced breeding season for phytoplankton and loss of larvae for higher order fish. Potential implications for the aquatic food chain have not been studied.

Initial case studies show that increased UV-B radiation will increase background levels of urban groundlevel ozone and will accelerate the breakdown plastics used in outdoor applications.

EPA

Presentation to DPC Working Group

prepared by
EPA
and
Subcommittee on Effects
(OSTP, DPC staff, Interior, CEA)

June 2, 1987

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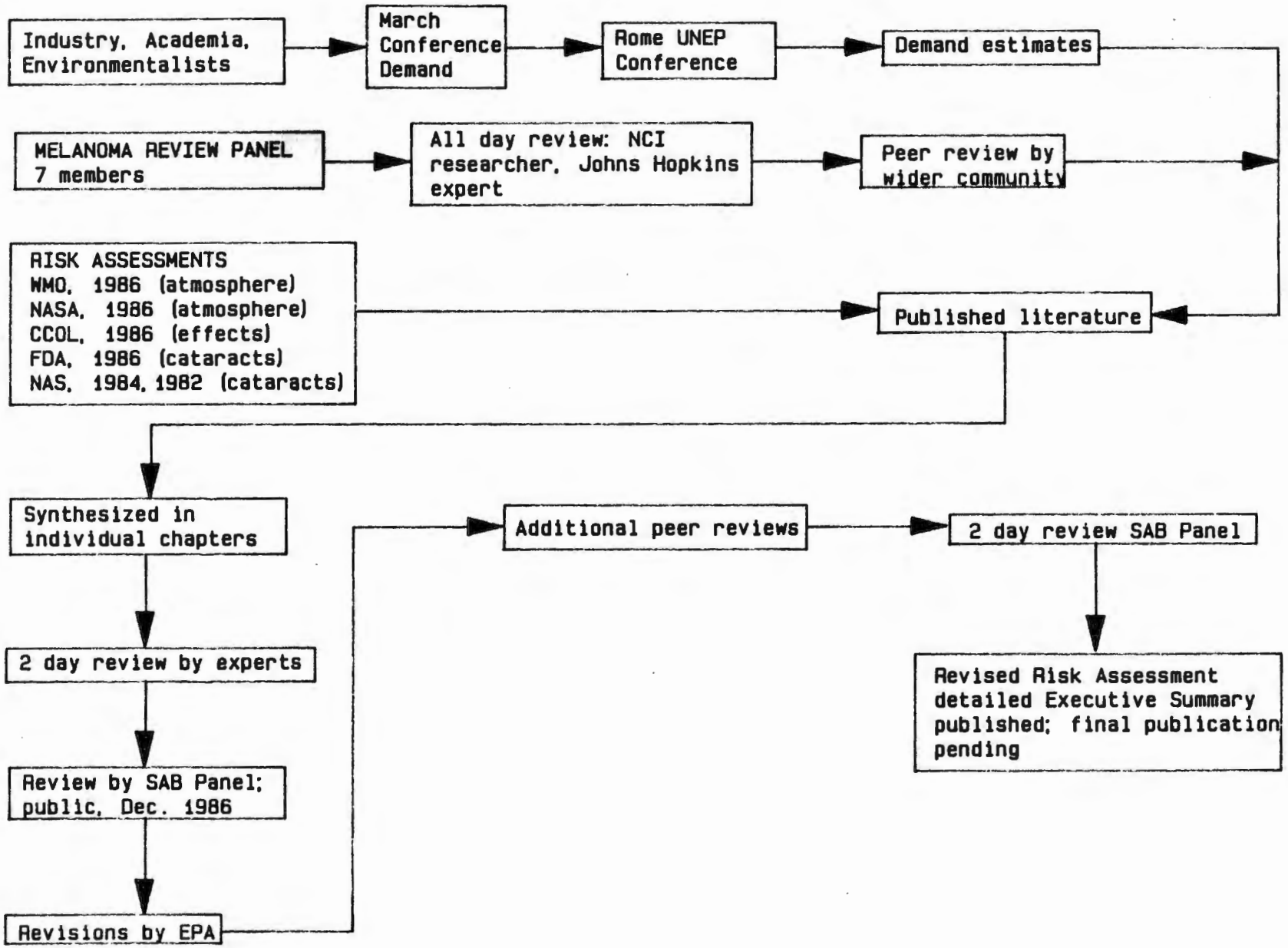
REVIEW PROCESS



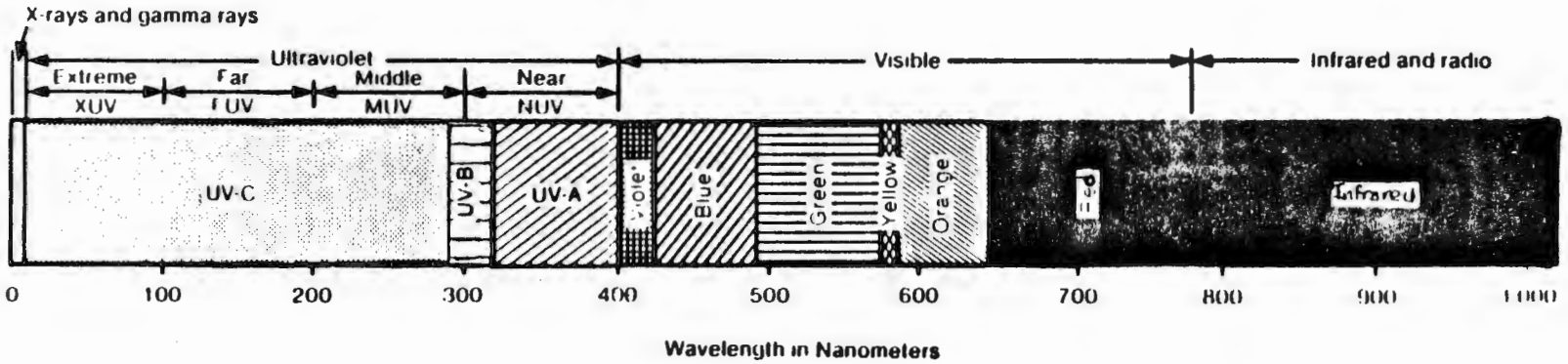
Science Advisory Board Review Panel Overview

	Potential Global Impact*	State of Knowledge
* UV-B radiation		
* Skin cancer	Moderate	Moderate to High
* Cataracts	Low	Moderate
* Immune suppression	High	Low
* Ground-based ozone	Low	Moderate
* Crops	High	Low
* Aquatics	High	Low
* Polymers	Low	Moderate
* Climate	Moderate**	Moderate

*Impacts can be large in U.S. and Small globally, (e.g. skin cancers occur for light-skinned people and ground-based ozone is not a global issue

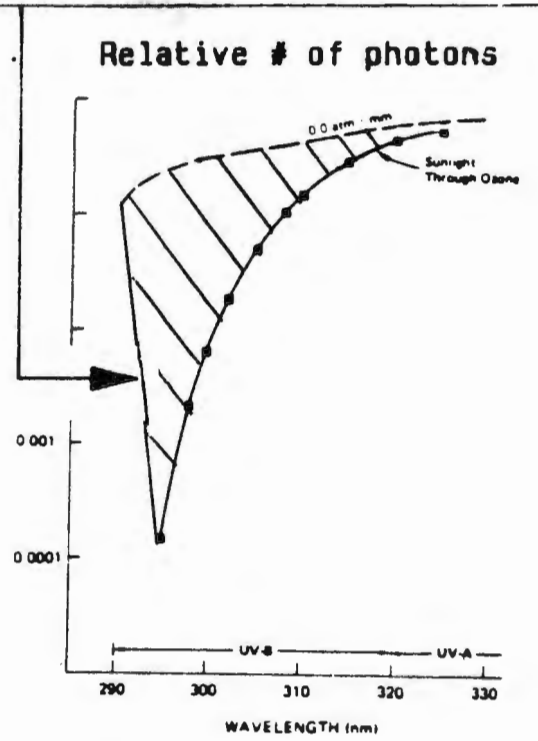
** includes effects of column ozone redistribution, not CFCs on warming

THE ELECTROMAGNETIC SPECTRUM



Source: Adapted from Scotto, 1986.

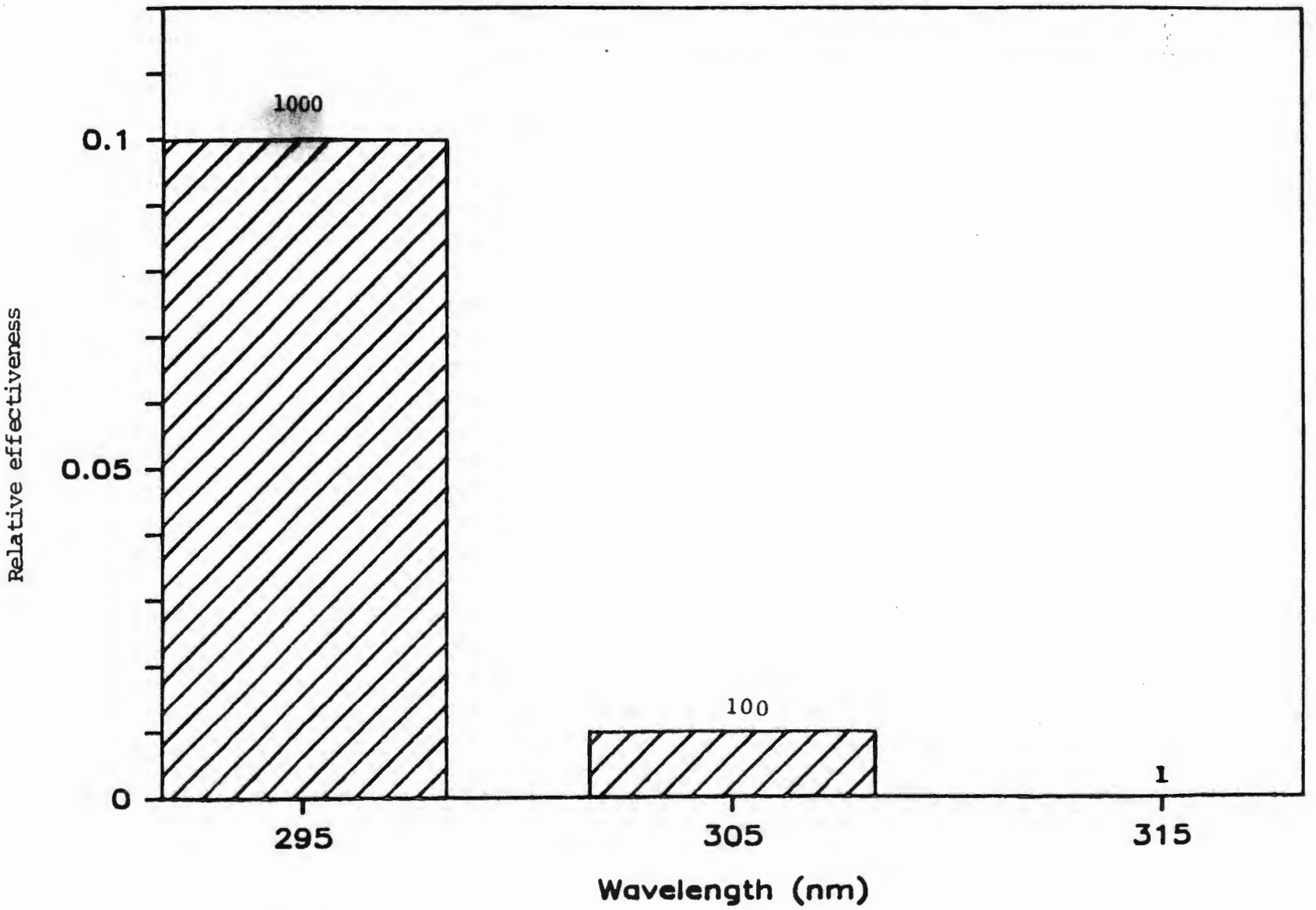
Effectiveness of Ozone Layer in Blocking UV Radiation



* Ozone layer varies seasonally, annually, and daily
* Variation also occurs by latitude, altitude and cloudiness

Source: Adapted from NAS, 1983

Relative Damage to DNA



DNA Action Spectrum: 1% ozone depletion leads to 2% - 3% increase in damaging ultraviolet radiation

Source: Setlow (1974)

UV-B CAUSES SKIN CANCERS

	Strength of Evidence on Cause	Dose	Responsiveness to 1% ozone column change (incidence)	Mortality
Basal	Conclusive	Cumulative	1.5 to 4.2 %	minimal (0.31% of cases)
Squamous	Conclusive	Cumulative	3.1 to 6.0 %	intermediate (3.75% of cases)
Melanoma	Very strong	Epsiodic	1.1 to 2.0 %	worst (1% depletion yields 0.7 to 0.9% increased mortality)

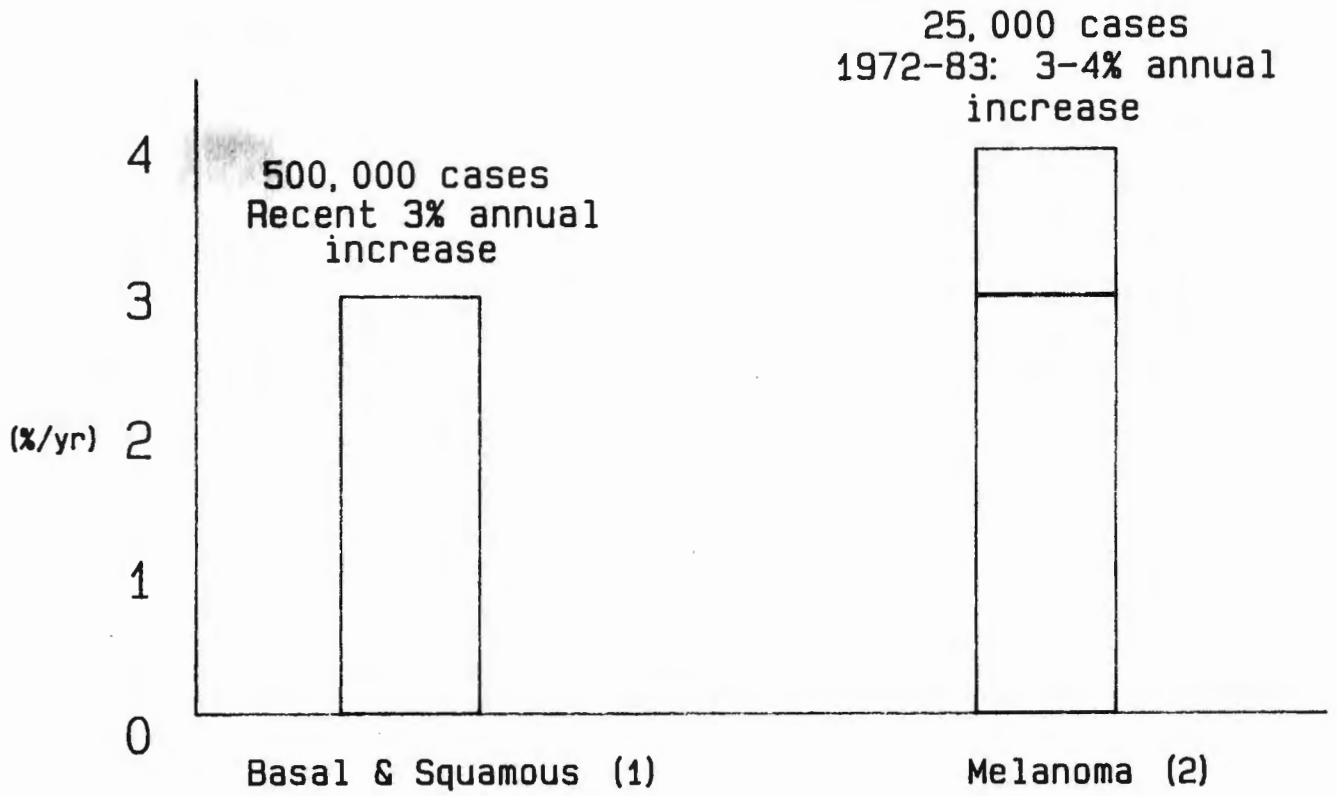
Sources: Estimates from EPA Risk Assessment and Scotto, (1986), "Nonmelanoma Skin Cancer - UV-B Effects" and Pitcher (1987), "Melanoma Death Rates and Ultraviolet Radiation in the United States"

EVIDENCE ON UV-B AND MELANOMA

Xeroderma patients (lack DNA repair for UV-B)	* 40 times rate in normal population
Sunburn history / Skin color	* Higher rates
Cases controls in Australian studies	* Weekend sailors have higher rates * Episodically exposed sites have highest rate
Indoor workers higher risk	* Related to episodic exposure

CURRENT BELIEF FOR KEY FACTOR: EPISODIC EXPOSURES

SKIN CANCER RATES ARE INCREASING IN U.S.



... causes are increasing affluence, changing leisure and clothing patterns, NOT ozone depletion

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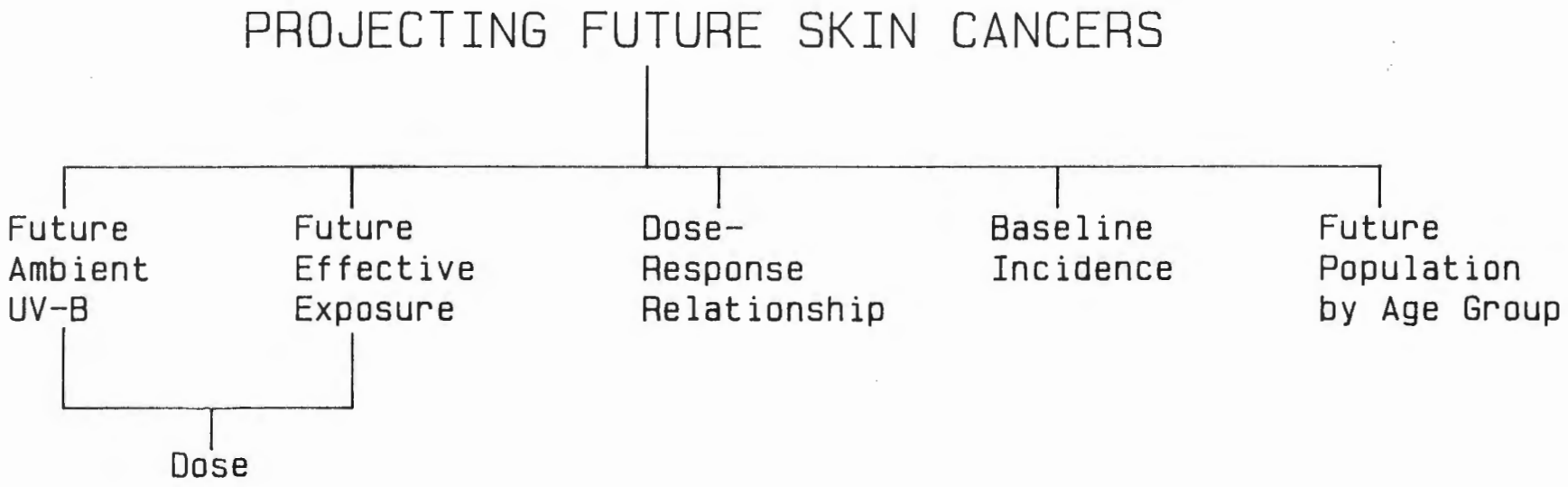
(1) Scotto, 1986
(2) Sondik et al., 1985
(3) Largest increase is in Hutchinson's melanotic freckle, which is not generally fatal and has a different etiology


PROJECTING FUTURE SKIN CANCERS
Future Ambient UV-B
Future Effective Exposure
Dose
Dose-Response Relationship
Baseline Incidence
Future Population by Age Group

* Dose response utilizes many forms of information

  -- case control studies
  -- animal studies (squamous)
  -- ecological studies

* Strengths of dose response relationship

  -- human data over relevant range of UV-B rather than large doses in mice to small doses in humans
  -- consistency of data and large explanatory power of data despite the fact they do not include all co-factors

* Weaknesses of dose response relationship

  -- uncertainty of action spectrum
  -- co-factors not completely represented

FUTURE EFFECTIVE DOSE = AMBIENT UV-B x EXPOSURE

* AMBIENT UV-B DEPENDS ON OZONE LAYER

* EXPOSURE IS INCREASING

  -- boating
  -- golf
  -- tennis
  -- income

* "EDUCATION" CAN REDUCE EXPOSURE

  -- Mrs. Reagan's personal involvement
  -- Newsweek, TV, etc., every year
  -- rates of exposure may not be growing as fast
  -- Australian experience indicates limited effectiveness
  -- sun blocks lead to greater time in sun

* "EDUCATION" CAN IMPROVE TREATMENT

  -- early detection is key to treatment
  -- education increases early detection
  -- once metastasized, these are very aggressive cancers

* CURRENT PROJECTIONS FREEZE INCREASE IN EXPOSURE, WHICH IS UNLIKELY EVEN THOUGH IT HAS BEEN INCREASING

CONCLUSIONS:
* EFFECTIVE DOSE IS PROBABLY UNDERESTIMATED
* OZONE DEPLETION WILL INCREASE EFFECTIVE DOSE REGARDLESS OF EXPOSURE. EVEN IF EDUCATION COULD REDUCE EXPOSURE, OZONE DEPLETION WILL INCREASE EFFECTIVE DOSE BEYOND WHAT IT OTHERWISE WOULD BE WITHOUT OZONE DEPLETION

ASSUMPTIONS POSSIBLY LEADING TO UNDERESTIMATION OR OVERESTIMATION

* BASELINE INCIDENCE IS FROZEN IN PROJECTIONS

  -- in reality the increase in skin cancer rates has not caught up with this behavior

  -- assumes education successfully arrests increasing exposure

* AGE COMPOSITION AND SKIN COLOR ARE HELD CONSTANT

  -- as average age of U.S. population actually increases, higher rates of skin cancer will be experienced

* ACTION SPECTRUM

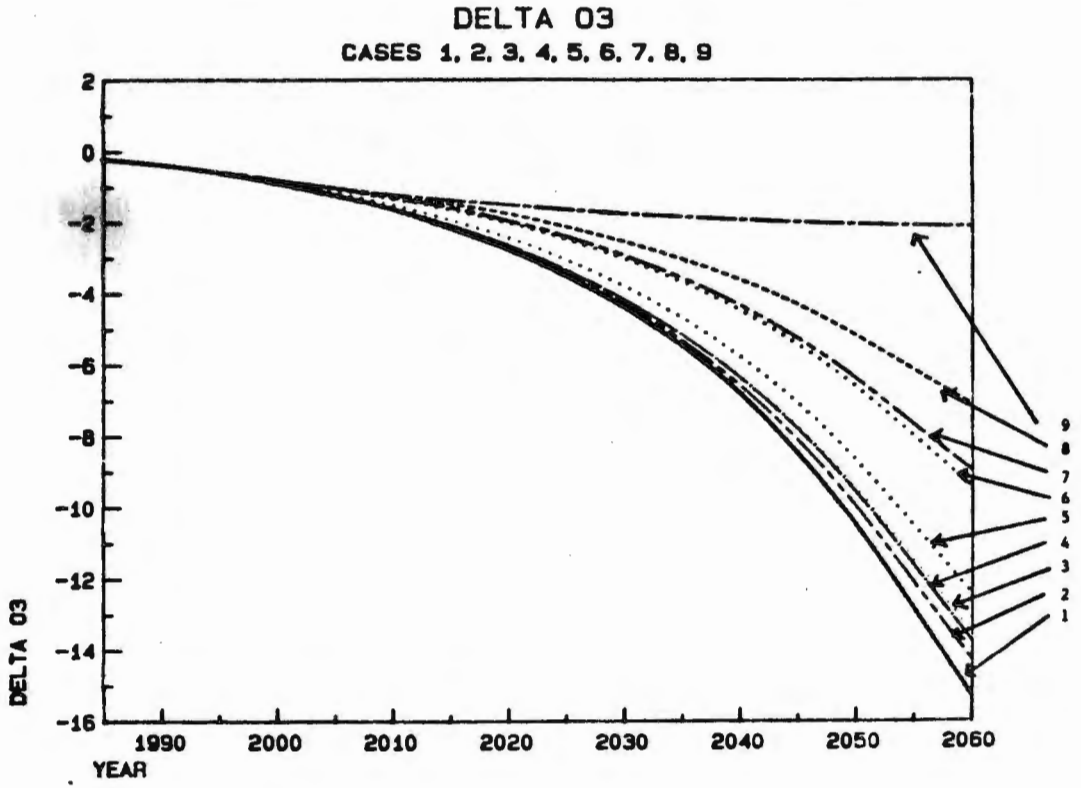
  -- DNA chosen

  -- alternative would be erethyma (~25% fewer cancers)

* MODEL USED FOR ESTIMATING OZONE DEPLETION IS LOWEST OF ALL MODELS INTERCOMPARED BY UNEP PANEL (SIMILAR TO 20% LOW)

* SURVIVAL RATES CONSTANT (NO MEDICAL ADVANCES OR NEW COFACTORS WORSENING DISEASE DEVELOP)

Comparison between a True Global Freeze and Protocol Options



Source: "Ad Hoc Scientfic Meeting to Compare Model Generated Assessments of Ozone Layer Change for Various Strategies for CFC Control, Wurzburg, Federal Republic of Germany, April 8-9, 1987" UNEP/WG 167/INF, 10 April 1987

1. Freeze CFC-11,12. 80% compliance in developed nations. Developing nations at 20% compliance, growth to 1/4 per capita of developed nations; linear methane
2. Freeze CFC-11,12. 80% compliance in developed nations. Developing nations at 20% compliance, growth to 1/4 per capita of developed nations; compound methane
3. Freeze CFC-11,12. 100% compliance in developed nations. Developing nations at 20% compliance, growth to 1/4 per capita of developed nations; linear methane
4. Freeze CFC-11,12,113. 80% compliance in developed nations. Developing nations at 20% compliance, growth to 1/4 per capita of developed nations; linear methane
5. 25% reduction CFC-11,12,113. 80% compliance in developed nations. Developing nations at 40% compliance, growth to 1/4 per capita of developed nations; linear methane
6. 50% reduction CFC-11,12,113, Halon-1211,1301. 80% compliance in developed nations; developing nations at 40% compliance, growth to 1/4 per capita of developed nations; linear methane
7. 50% reduction CFC-11,12,113, Halon-1211,1301. 80% compliance in developed nations; developing nations at 40% compliance, growth to 1/4 per capita of developed nations; compound methane
8. 50% reduction CFC-11,12,113, Halon-1211,1301. 100% compliance in developed nations; developing nations at 40% compliance, growth to 1/4 per capita of developed nations; linear methane
9. Freeze on CFC-11,12,113, Halon-1211,1301, CFC-22, carbon tetrachloride, methyl chloroform. 100% compliance in all nations, including developing nations; linear methane

ASSUMPTIONS USED IN PROJECTING EFFECTS OF PROTOCOL DESIGNS

FREEZE: covers CFC-11, 12, 113. Compliance rates are 100% in U.S., 80% in rest of developed world, and 20% in developing nations. Growth of non-compliers is 1/4 of baseline growth in developed nations; 3/4 of baseline growth in developing nations. In developed nations, freeze begins in 1990 at 1986 levels; for developing nations in 2000 at 2000 levels.

20% REDUCTION: covers CFC-11, 12, 113. Compliance rates are 100% in U.S., 80% in rest of developed world, and 20% in developing nations. Growth of non-compliers is 1/4 of baseline growth in developed nations; 3/4 of baseline growth in developing nations. In developed nations, freeze begins in 1990 at 1986 levels, followed by 20% reduction from 1986 levels by 1992; for developing nations freeze in 2000 at 2000 levels, followed by 20% reduction in 2000 levels by 2002.

50% REDUCTION: tested for two levels of coverage: (1) CFC-11, 12, 113, and (2) CFC-11, 12, 113, Halon-1211, 1301. Compliance rates are 100% in U.S., 80% in rest of developed world, and 50% in developing nations. Growth of non-compliers is 1/4 of baseline growth in both developed and developing nations. In developed nations, freeze begins in 1990 at 1986 levels, followed by 20% reduction from 1986 levels by 1992, and 50% reduction from 1986 levels by 1998; for developing nations freeze in 2000 at 2000 levels, followed by 20% reduction from 2000 levels by 2002, and 50% reduction from 2000 levels by 2008.

PROJECTED AMERICAN DEATHS AVERTED

Among cohorts born before 2075

Protocol Option Stringency	Coverage	Skin cancer deaths averted	Uncertainty (1)
Protocol freeze	CFC-11, 12, 113	947,000	(829,000 to 1,204,000)
20 percent	CFC-11, 12, 113	993,000	(870,000 to 1,269,000)
50 percent	CFC-11, 12, 113	1,072,000	(942,000 to 1,372,000)
50 percent	CFC-11, 12, 113 Halon-1211, 1301	1,136,000	(1,000,000 to 1,454,000)

(1) Low end of range results from uncertainties regarding choice of action spectrum. High end of range results from uncertainties regarding choice of 1-D model used for estimating ozone depletion

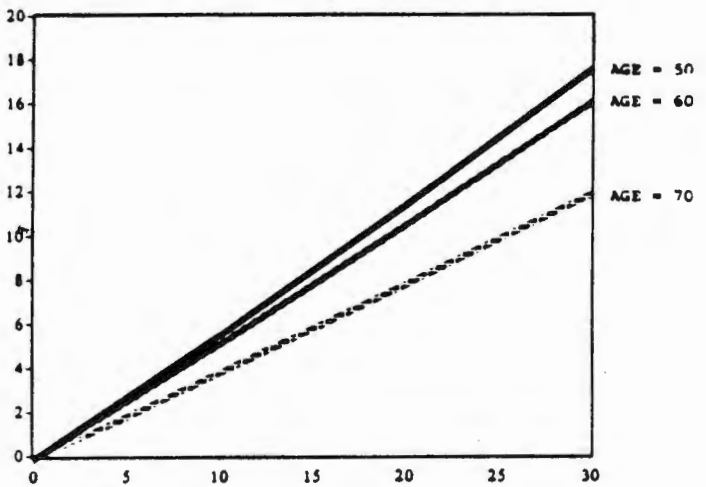
PROJECTED NON-FATAL CASES OF SKIN CANCER IN AMERICA AVERTED

Among cohorts born before 2075

Protocol Option Stringency	Coverage	Non-fatal skin cancer cases averted	Uncertainty (1)
Protocol freeze	CFC-11, 12, 113	47, 920, 000	(42, 454, 000 to 59, 923, 000)
20 percent	CFC-11, 12, 113	53, 560, 000	(44, 770, 000 to 63, 527, 000)
50 percent	CFC-11, 12, 113	54, 949, 000	(48, 832, 000 to 69, 342, 000)
50 percent	CFC-11, 12, 113 Halon-1211, 1301	58, 609, 000	(52, 156, 000 to 74, 024, 000)

(1) Low end of range results from uncertainties regarding choice of action spectrum. High end of range results from uncertainties regarding choice of 1-D model used for estimating ozone depletion

CUMULATIVE EXPOSURE TO UV-B IS RELATED TO THE PREVALENCE OF SENILE CATARACTS



* Current prevalence 9.3 million in U.S.

* Uncertainty in estimation ~ 20%

Source: Based on Hiller (1983) Analysis of NHANES Data

PROJECTED CATARACTS AVERTED IN AMERICA

Among cohorts born before 2075

Protocol Option		Cataract cases averted	Uncertainty
Stringency	Coverage		
Protocol freeze	CFC-11, 12, 113	12, 455, 000	(+ or - 20%)
20 percent	CFC-11, 12, 113	13, 332, 000	(+ or - 20%)
50 percent	CFC-11, 12, 113	14, 917, 000	(+ or - 20%)
50 percent	CFC-11, 12, 113 Halon-1211, 1301	16, 323, 000	(+ or - 20%)

POSSIBLE IMPACTS OF UV-B SUPPRESSION OF IMMUNE SYSTEM

* Herpes simplex (demonstrated in humans)
  source: Spruance (1985)

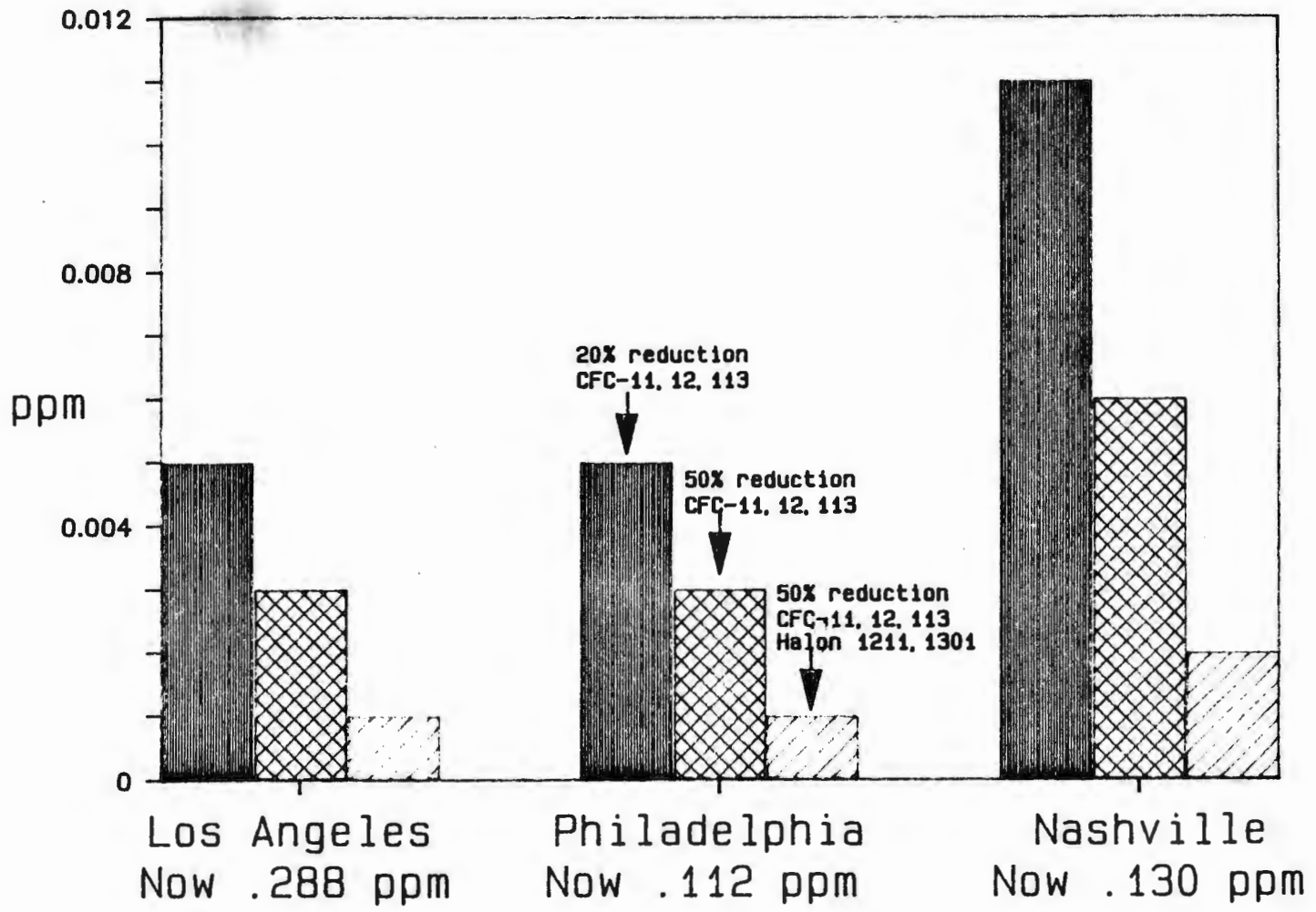
* Leishmaniasis (animal model)
  source: Giannini (1986)

* Skin cancers

* Other infectious diseases (?)

* Other cancers (?)

Increase in Ground-Based Ozone
(research in early stages)



Based on analysis of Whitten (1986), in UNEP Vol. 2

CROPS

* Most studies in greenhouse

* 2/3 of tested cultivars vulnerable

* Very few field studies (soybeans)

* Data from greenhouse cannot always reliably be extrapolated

* More data will take a long time

FIELD STUDY OF SOYBEANS:

SUMMARY OF UV-B EFFECTS ON YIELD AND QUALITY OF SENSITIVE CULTIVARS

FOR 20% OZONE REDUCTION

YEAR	Change in yield from control (%)	Change in seed quality from control (%)	
		Proteins	Oils
1981	-25	no data collected	
1982	-23	-5	-2
1983	+6	-4	+1
1984	-7	0	-2
1985	-20	0	0

Drought years: extremely low yields

Source: Teramura, (1986), "Overview of our current state of knowledge of UV effects on Plants", in UNEP, Vol. 1.

1/3 of cultivars are not sensitive to UV-B

AQUATICS (based on laboratory studies)

* Plant community composition change
  Source: Worrest et al., 1981, and EPA Risk Assessment

* Zooplankton

  -- shorter breeding season due to sensitivity
  -- loss of breeding season
  Source: Damkear et al., 1980, and EPA Risk Assessment

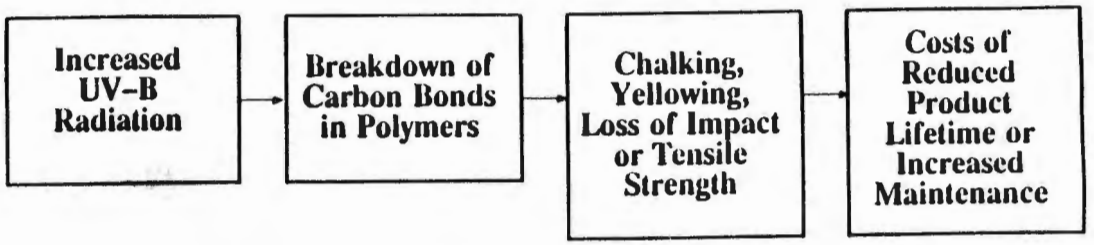
* Higher fish

  -- direct damage to larval stage
  -- indirect damage through food chain
  Sources: see EPA Risk Assessment

* Effects possibly large, but quantitatively uncertain

  -- detailed studies lacking
  -- species in extreme latitudes possibly most sensitive

UV-B AND ACCELERATED WEATHERING OF POLYMERS



Case Study: **PVCs Used Outdoors in Siding and Window Frames**

Assumes: **Use of Stabilizers to Offset losses**
Ozone Depletion Based on Mid-Range Cases

Costs: **Cumulative Costs* of $4.7 Billion in U.S. (1984–2075)**

*Undiscounted

Based on projected ozone depletion for "reference case": 2.5% per year growth in CFC-11 and CFC-12 emissions; 1% per year increase in methane concentrations; historical increases in other trace gases. 26% depletion by 2075.

Source: Andrady and Horst, 1986.

Other polymers that will be influenced

Polymer	Application	Damage
PVC	(a) siding, window frames	[yellowing] + chalking - impact properties - tensile properties + surface distortion
	(b) roofing materials	[+ brittleness] [+ discoloration]
UPE	outdoor surfaces paneling	[+ surface erosion] + discoloration - strength
PE/PP	irrigation pipe, outdoor furniture synthetic turf, stadium seats, packaging	[+ brittleness] - tensile properties - electrical properties
PC	glazing material	[+ yellowing] - transparency

+ = increase
- = decrease
[] = Brackets indicate critical mode of damage (CMD)

GREENHOUSE EFFECT ENHANCED EXECPT AT HIGH LEVELS OF DEPLETION

* Ozone column redistribution

  -- greenhouse effect enhanced
  -- circulation changes possible

* CFCs are a greenhouse gas

* Decreasing CFCs from 20% to 50% averts
  0.15 to 0.45 degrees C (0.27 to 0.81 degrees F)
  of global temperature rise

HOW LONG TO BETTER INFORMATION (*)

Current R&D Low	Field Experiments	Health	Air Pollution	If Resources Start Expanding Significantly in 1989 (By an order of magnitude)
EPA Budget <1,000,000	Expensive	Critical needs	Kinetics	SIGNIFICANTLY BETTER INFORMATION BY 2000
			Empirical	
Compared to atmospheric research of more than 30,000,000 NASA, NOAA, not including satellites (>60,000,000)	5 years to data each crop	Infectious diseases		Improvements by 1996 (primarily on air pollution, estimation, dose-response, a few crops)
	Natural aquatic studies	Individual exposure		
		Epidemiological studies		

(*) OSTP asked for inclusion