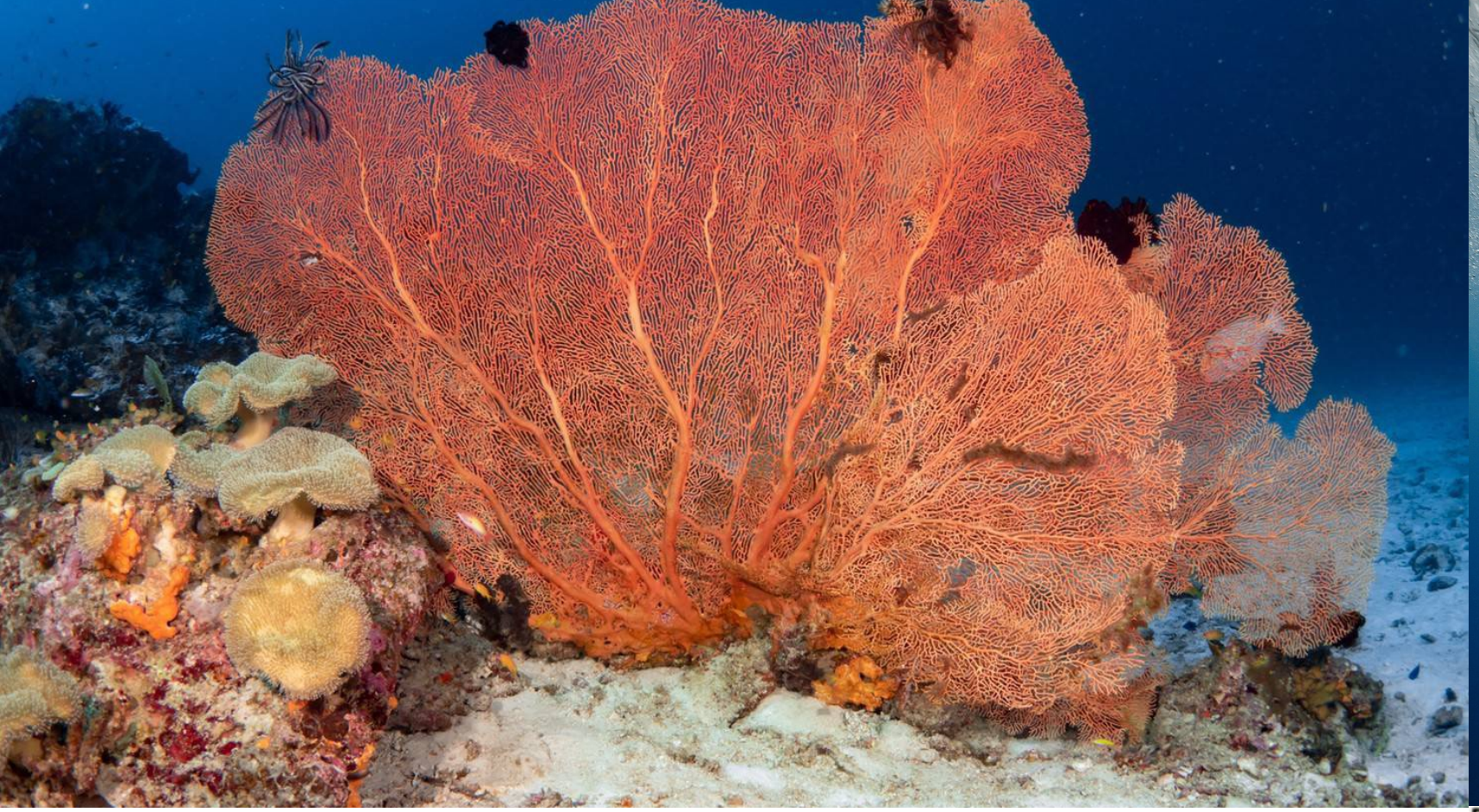
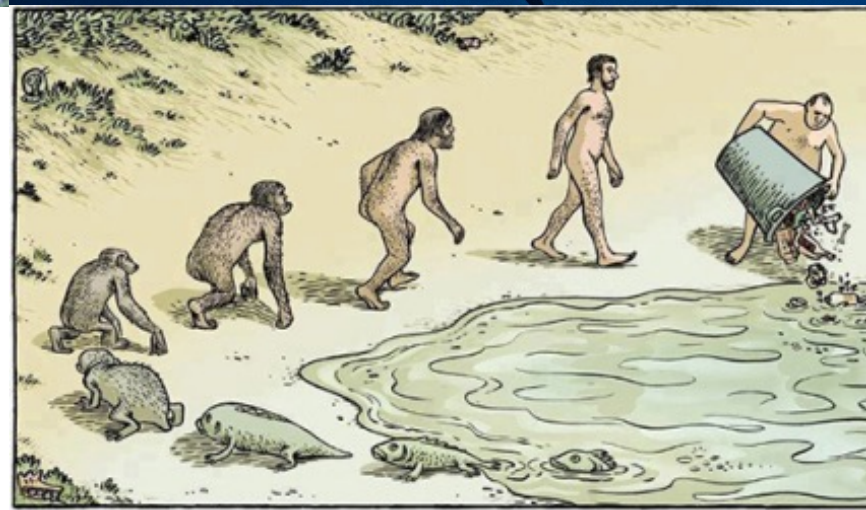
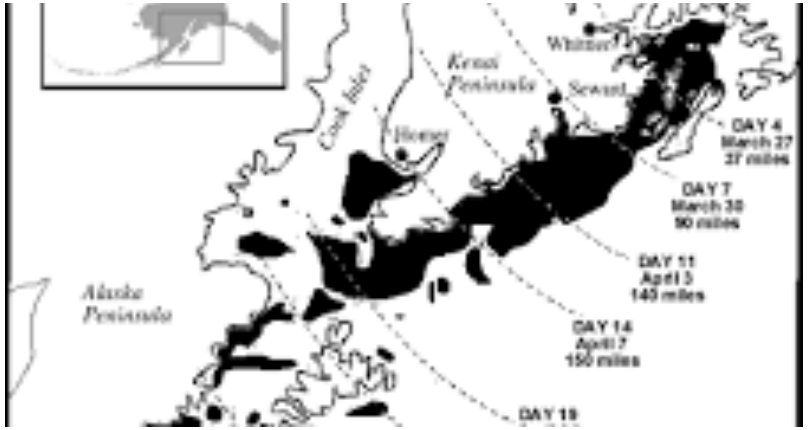


EE476
Environmental Economics

Lecture Non-Market Valuation 4

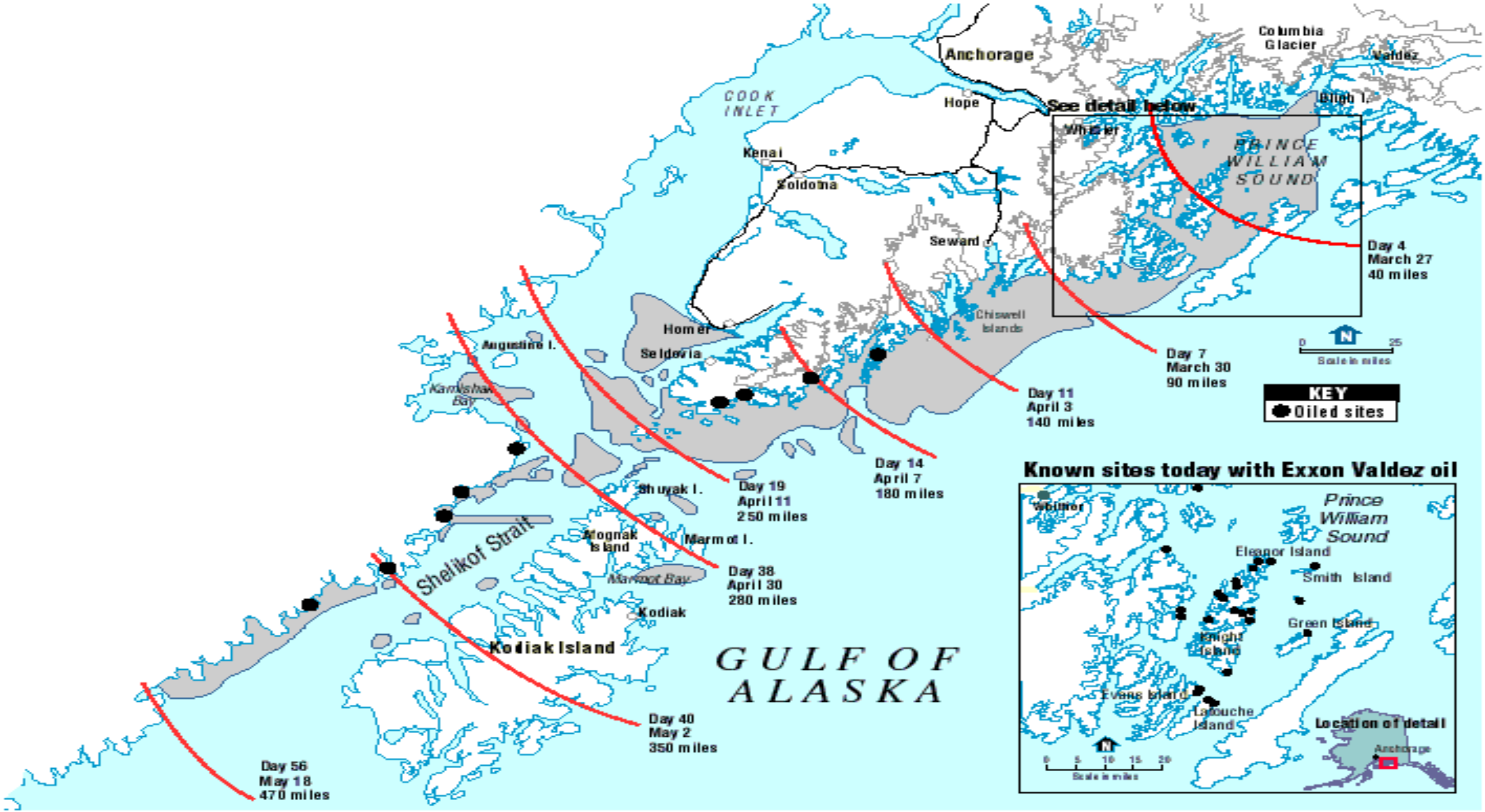
2022





Exxon Veldez

Spread of oil from the Exxon Valdez



Source: Alaska Department of Environmental Conservation, National Marine Fisheries Service

RON ENGSTROM / Anchorage Daily News

Exxon Valdez Oil Spill, 1989

10.8 million gallons of oil spilled

- Bligh Reef Collision - Start of Oil Spill
- Oil Spill Boundary
- Anadromous Fish Streams
- Seabird Colonies
- Important Bird Areas
- Sea Otter Critical Habitat
- Beluga Whale Critical Habitat
- North Pacific Right Whale Critical Habitat
- Steller Sea Lion Critical Habitat

0 37.5 75 150 Miles

0 50 100 200 Kilometers

ALASKA

Kenai Peninsula

Cook Inlet

Alaska Peninsula

Bristol Bay

Kodiak Island

Exxon Valdez Oil Spill Boundary

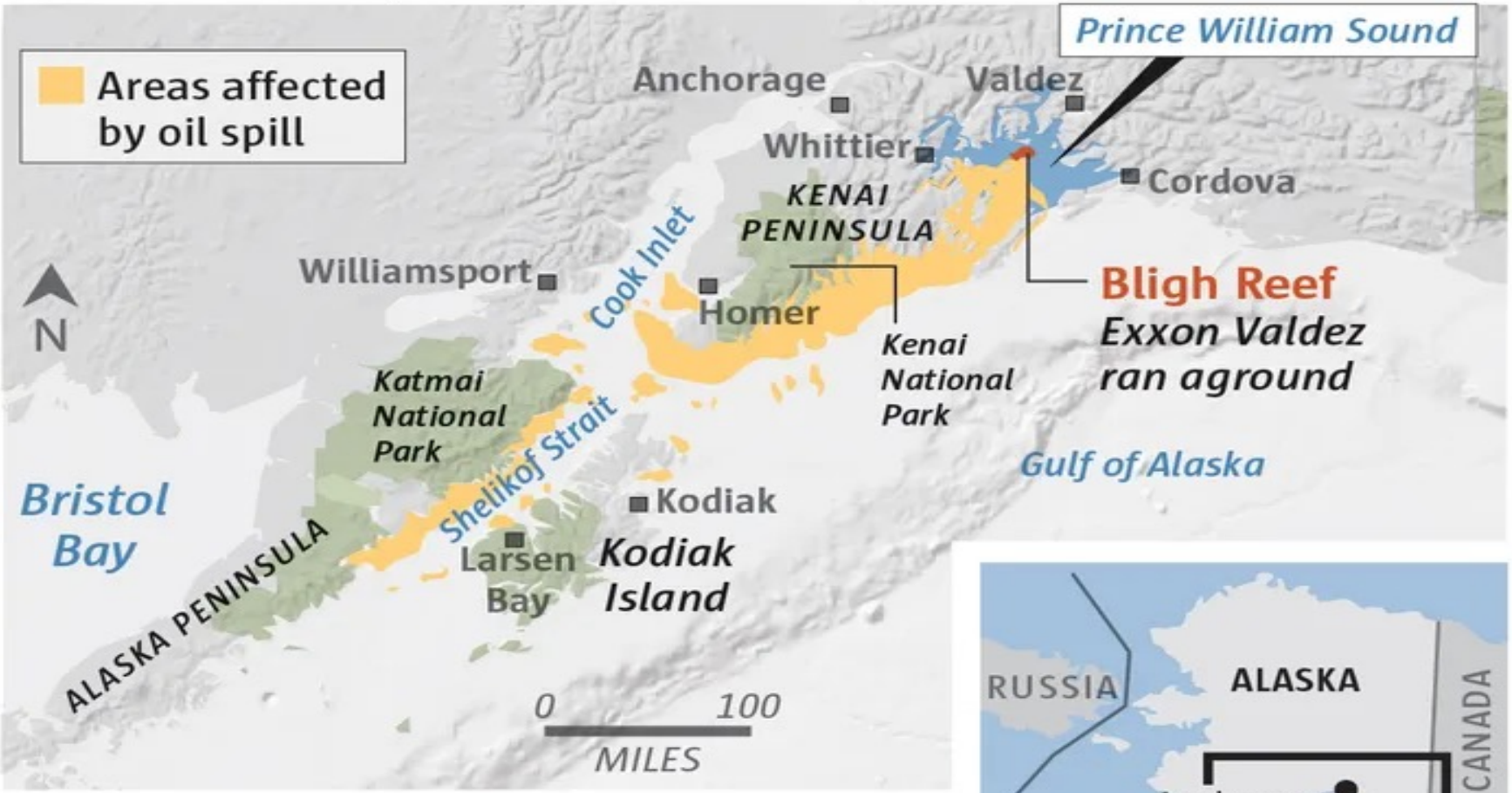
Gulf of Alaska

OCEANA | Protecting the World's Oceans

Data sources: ADFG Anadromous Streams Catalog, 2011; ADNR oil spill boundary shapefile, 1993; Audubon, Alaska, 2009; NOAA Fisheries, Alaska Region Critical Habitat, 1993.
Photo sources: Animals in oil, Exxon Valdez Oil Spill Trustee Council; Hand in oil, David Janka/NOAA.

1989 Exxon Valdez oil spill

The worst shoreline damage was in Prince William Sound, but the 11 million gallon oil spill spread to the south and west. Some 200 miles of shoreline were polluted by oil, while another 1,100 miles were less polluted.



Sources: Esri, Anchorage Daily News, The Associated Press, Alaska Department of Natural Resources, McClatchy-Tribune News service

MARK NOWLIN / THE SEATTLE TIMES

Timeline of events 1989-2008

- **March 24, 1989:** Exxon Valdez tanker runs aground; nearly 11 million gallons of crude oil spilled.
- **1990:** Capt. Joe Hazelwood found not guilty of drunken driving and grounding; guilty of negligent discharge of oil.
- **1991:** Exxon agrees to plead guilty to four environmental crimes, pay government $125 million in criminal fines, pay $900 million to settle civil lawsuits filed by government; money used for cleanup, restoration, scientific studies.
- **1994:** About 3,500 Alaska Natives settle suit for $20 million for damage to subsistence hunting, gathering; separately, fishermen, land and business owners win $287 million in damages, $5 billion in punitive damages; Exxon vows to appeal.
- **June 25, 2008:** U.S. Supreme Court rules that punitive damages against Exxon cannot exceed compensatory damages for actual losses from the spill, which totaled $507.5 million.

The contingent valuation method (CVM)

- CVM is a survey-based stated preference technique that elicits people's intended future behaviour in constructed markets.
- Respondents are asked directly for their willingness-to-pay (or willingness-to-accept) for a hypothetical change in the level of provision of the good. Respondents are assumed to behave as though they were in a real market.

Designing a contingent valuation questionnaire

“the principal challenge facing the designer of a CV study is to make the scenario sufficiently understandable, plausible and meaningful to respondents so that they can and will give valid and reliable values despite their lack of experience with one or more of the scenario dimensions”.

3 basic parts to most CV survey instruments.

1. First, it is customary to ask a set of attitudinal and behavioural questions about the good to be valued as a preparation for responding to the valuation question.
2. Second, The scenario includes a description of the commodity and of the terms under which it is to be hypothetically offered. Information is also provided on the quality and reliability of provision, timing and logistics, and the method of payment.
   - Then respondents are asked questions to determine how much they would value the good if confronted with the opportunity to obtain it under the specified terms and conditions.
   - Respondents are also reminded of substitute goods and of the need to make compensating adjustments in other types of expenditure to accommodate the additional financial transaction.

3 basic parts to most CV survey instruments.

3. Questions about the socio-economic and demographic characteristics of the respondent are asked in order to ascertain the representativeness of the survey sample relative to the population of interest, to examine the similarity of the groups receiving different versions of the questionnaire and to study how willingness-to-pay varies according to respondents' characteristics.

- Econometric techniques are then applied to the survey results to derive the desired welfare measures such as mean or median WTP
- we focus on the second and core part of a CV questionnaire that comprises three interrelated stages:

  i) identifying the good to be valued;

  ii) constructing the hypothetical scenario; and

  iii) eliciting the monetary values.

Constructing the hypothetical scenerio

- As with all surveys, CV surveys are context dependent.
- the values estimated are contingent on various aspects of the scenario presented and the questions asked. These include the information provided about the good, the wording and type of the valuation questions, the institutional arrangements and the payment mechanism..
- A hypothetical scenario has three essential elements:

  i) a description of the policy change of interest;

  ii) a description of the constructed market; and

  iii) a description of the method of payment.

What is the policy change being valued?

- Researchers must have a very clear idea of what policy change they want to value, i.e. which quality or quantity change(s) is of interest and of what particular non-market good(s) or service(s).
- There may be scientific uncertainty surrounding the physical effects of particular changes and it may be unclear how physical changes affect human well-being.
- the effects of some changes may be difficult to translate into terms and sentences that can be readily understood by respondents.
- some changes are very complex and multidimensional and cannot be adequately described within the timeframe and the means available to conduct the questionnaire.
- textual descriptions of some changes may provide only a limited picture of the reality (e.g. changes in noise, odor or visual impacts).

Damages caused by the introduction of a plant pest	Limited scientific information may not permit full identification of the wide range of environmental impacts caused by plant pests; Difficulty in explaining in lay terms the idea of damages to biodiversity and ecosystems; The impacts of a pest may be too complex to explain in the limited time that the questionnaire lasts.

Description of the constructed market

- *The institution that is responsible for proving the good*. This can be a government, a local council, a non-governmental organization or NGO, a research institute, industry, a charity and so on. Institutional arrangements will affect WTP as respondents may hold views about particular institutions' level of effectiveness, reliability and trust.
- *Conditions for provision of the good include respondents' perceived payment obligation and respondents' expectations about provision.*
  - *Respondents' perceived payment obligation :* respondents may believe they will have to pay the amounts they state; they may think the amount they have to pay is uncertain (more or less than their stated WTP amount); or they may be told that they will pay a fixed amount, or proportion of the costs of provision.
  - *Respondents' expectations about provision. :* respondents may believe that provision of the good is conditional on their WTP amount➔ evokes a different type of strategic behaviour.

Description of the constructed market

- *The timing of provision* – when and for how long the good will be provided – also needs to be explicitly stated.
  - Given individual time preferences, a good provided now will be more valuable than a good provided in 10 years' time.
  - Also, the amount of time over which the good or service will be provided can be of crucial importance. For example, the value of a programme that saves black rhinos for 50 years is only a fraction of the value of the same programme where protection is awarded indefinitely.

Description of the method of payment

- How the provision of the good is to be financed? –voluntary or coercive payments.
- Coercive payment vehicles include taxes, rates, fees, charges or prices.
- Voluntary payments are donations and gifts.
- The payment vehicle is generally believed to be a non-neutral element of the survey.
- Mechanisms such as income taxes and water rates are clearly non-neutral and it is relatively common to find respondents refusing to answer the valuation question on the grounds that they object in principle to paying higher taxes, in spite of the fact that the proposed change is welfare enhancing.
- Voluntary payments on the other hand might encourage free-riding, as respondents have an incentive to overestimate their WTP to secure provision.
- A simple guideline is to use the vehicle, which is likely to be employed in the real-world decision:

Eliciting monetary values

- respondents are asked questions to determine how much they would value the good if confronted with the opportunity to obtain it.
- The elicitation question can be asked in a number of different ways.

Format	Description
Open ended	*What is the maximum amount that you would be prepared to pay every year, through a tax increase (or surcharge), to improve the landscape around Stonehenge in the ways I have just described?*
Bidding game	*Would you pay GBP 5 every year, through a tax increase (or surcharge), to improve the landscape around Stonehenge in the ways I have just described?* If Yes: Interviewer keeps increasing the bid until the respondent answers No. Then maximum WTP is elicited. If No: Interviewer keeps decreasing the bid until respondent answers Yes. Then maximum WTP is elicited.
Payment card	*Which of the amounts listed below best describes your maximum willingness-to-pay every year, through a tax increase (or surcharge), to improve the landscape around Stonehenge in the ways I have just described?* 0 GBP 0.5 GBP 1 GBP 2 GBP 3

Eliciting monetary values

- respondents are asked questions to determine how much they would value the good if confronted with the opportunity to obtain it.
- The elicitation question can be asked in a number of different ways.

Single-bounded dichotomous choice	*Would you pay GBP 5 every year, through a tax increase (or surcharge), to improve the landscape around Stonehenge in the ways I have just described?* (The amount is varied randomly across the sample.)
Double-bounded dichotomous choice	*Would you pay GBP 5 every year, through a tax increase (or surcharge), to improve the landscape around Stonehenge in the ways I have just described?* (The amount is varied randomly across the sample.) If Yes: *And would you pay GBP 10?* If No: *And would you pay GBP 1?*

Source: Pearce et al. (2006).

Open ended

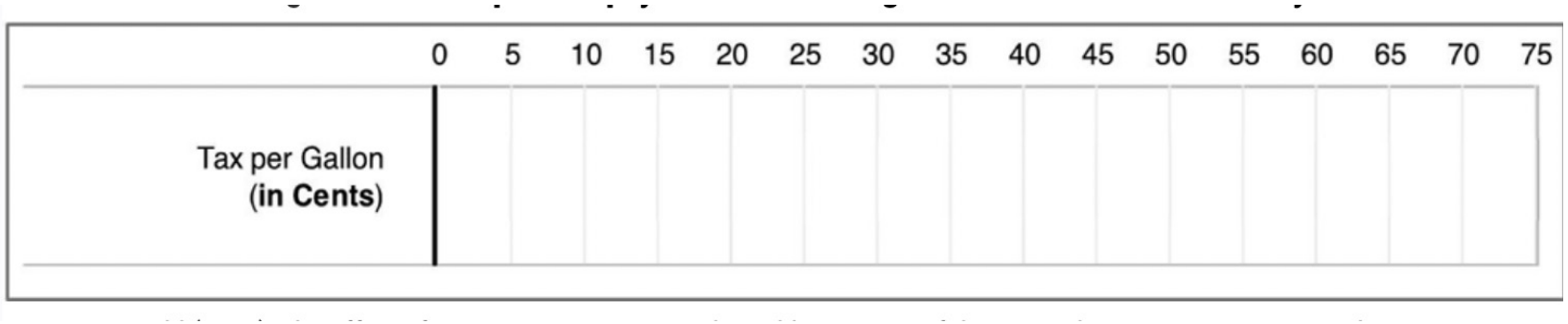
- respondents are not influenced by the starting values and succeeding bids used.
- Open-ended questioning leads to large non-response rates, protest answers, zero answers and outliers and generally to unreliable responses. This is because it may be very difficult for respondents to come up with their true maximum WTP for a change they are unfamiliar with and have never thought about valuing before.

bidding game

- respondents are faced with several rounds of discrete choice questions, with the final question being an open-ended WTP question.
- This iterative format was reckoned to facilitate respondents' thought processes and thus encourage them to consider their preferences carefully.
- A major disadvantage lies in the possibility of anchoring or starting bias. It also leads to large number of outliers, and to a phenomenon that has been labelled as "yea-saying", that is respondents accepting to pay the specified amounts to avoid the socially embarrassing position of having to say no.
- Bidding games have mostly been discontinued in contingent valuation practice.

Payment card

- Presenting respondents with a visual aid containing a large number of monetary amounts facilitates the valuation task, by providing a context to their bids, while avoiding starting point bias at the same time.
- The number of outliers is also reduced in comparison to the previous methods. In on-line surveys, payment cards can be presented as sliding scales, where respondents slide the cursor along to select their value'
- The payment card is nevertheless vulnerable to biases relating to the range of the numbers used in the card.



Single-bounded dichotomous choice or referendum methods

- This elicitation format is thought to simplify the cognitive task faced by respondents (respondents only have to make a judgement about a given price, in the same way as they decide whether or not to buy a supermarket good at a certain price)
- This procedure minimises non-response and avoids outliers. Some degree of yea-saying is also possible.
- In addition, dichotomous choice formats are relatively inefficient in that less information is available from each respondent (the researcher only knows whether WTP is above or below a certain amount), so that larger samples and stronger statistical assumptions are required. This makes surveys more expensive and their results more sensitive to the statistical assumptions made.

Double-bounded dichotomous choice

- formats are more efficient than their single-bounded counterpart as more information is elicited about each respondent's WTP.
- For example, one knows that a person's true value lies between GBP 5 and GBP 10 if she accepted to pay GBP 5 in the first question but rejected GBP 10 in the second.
- But all the limitations of the single-bounded procedure still apply in this case.

Elicitation format and example	Advantages	Limitations
Open-ended question *"How much are you willing to pay?"*	• Allows for smaller sample size than other formats. • Simple point-estimates	• Subject to non-response because it is harder than close-ended questions (e.g. yes/no questions).
Single-bounded dichotomous choice (referendum format) *"Are you willing to pay $___?"* *'yes' or 'no' vote to a single nominated value*	• Simple point-estimates	• Inflated mean WTP due to yeah-saying responses • Low statistical efficiency (Hanemann *et al.* 1991, Kanninen 1995)
Double-bounded dichotomous choice *"Are you willing to pay $x?"* *If yes, "Are you willing to pay $y (amount more than $x)?"* *If no, "Are you willing to pay $z (amount less than $x)?"*	• Increased information on the value. • Allow for smaller sample size than the single-bounded dichotomous choice	• Inflated mean WTP due to yeah-saying responses • Vulnerable to starting-point bias and range bias
Bidding format Like an auction the respondents are asked whether they are willing to pay a nominated amount, and depending on their answer, they are asked about lower/higher bids. This process continues until the maximum WTP amount is found.	• Higher response rate than an open-ended question • Closer to market situation	• Inflated mean WTP due to yeah-saying responses • Vulnerable to starting-point bias and range bias • Requires an interactive interview format (computer programming, or telephone/face-to-face interviews)
Payment card Showing respondents a series of values on a card and asking them to choose the value that most closely represents their WTP	• Higher response rate than an open-ended question • More valid (higher % of variance explained; stronger association with ability to pay) than estimates derived from open-ended questions (Donaldson *et al.* 1997)	• Vulnerable to range bias • Limited interview format in order to present the payment card to the respondents
Payment ladders Absolutely certain that I would	• Allow for range of uncertainty over the value respondents place	• Only an interval estimation between the maximum rejected bid and the

Bias in CVM

Types	Sources
Hypothetical bias and yeah-saying responses: Values offered in hypothetical survey contexts are significantly different from values offered in real market conditions (Blumenschein *et al.* 2001, Kennedy 2002). Yeah-saying responses refer to responding yes to a question without really meaning it.	• Lack of relevant information provided to the respondents before eliciting their willingness to pay (List and Gallet 2001, Hultkrantz *et al.* 2006). • Close-ended WTP survey questions are not administered in a manner that encourages the respondents to seriously think about and respond to the questions (Arrow *et al.* 1993).
Non-responses: Non-responses can include a genuine 'don't know' responses or strategic refusal responses (Dalmau-Matarrodona 2001), which are distinct from genuine real zero valuations.	• Lack of information provided to the respondents about the product and its implementation context (Arrow *et al.* 1993). • Open-ended WTP questions (Arrow *et al.* 1993).
Strategic responses (protest zeros/free-riding): Respondents understand the WTP question and support the product provision but demonstrate their refusal to pay themselves by giving a nil response in the hope that someone else (e.g. government) will pay for the product (Carson *et al.* 2001).	• Can be induced by the ways in which the product is framed in terms of private versus public with respect to provision and use. (Hultkrantz *et al.* 2006, Svensson and Johansson 2010, Pedersen *et al.* 2011).

Bias in CVM

Scope and scale biases: WTP estimates being insensitive to changing health outcomes in terms of • consequences (scope bias) *e.g.* minor injury versus serious injury, and • magnitude of risk reduction (scale bias) *e.g.* 5% versus 10% reduction (Beattie 1998, Olsen *et al.* 2004, Hultkrantz *et al.* 2006).	• The product outcomes in terms of risks and uncertainty are not clearly communicated in the CV surveys (Carson *et al.* 2001, de Blaeij and van Vuuren 2003) • The valuation is sought for changes in small probabilities of risks (Jones-Lee *et al.* 1995). • When respondents value the product in terms of moral satisfaction from the act of giving or from contributing to what the respondents believe as a good cause (warm glow effect), rather than the product itself (Kahneman and Knetsch 1992, Baron and Greene 1996).
Range bias: The final WTP estimate restricted by the range of values presented in the CV survey (Donaldson *et al.* 1997, Whynes *et al.* 2004).	• The bid values presented in the payment card or bidding formats do not cover all the possible values for the product in practice.
Starting point bias: The final response is influenced by the initial value presented in the bidding format (Boyle *et*	• The order of the bid presentations are the same across all survey respondents.

Environmental and Resource Economics **25:** 257–286, 2003.

Contingent Valuation and Lost Passive Use: Damages from the Exxon Valdez Oil Spill

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BOX A

SHOW PHOTO A

This photograph shows Valdez from the air. This is the town (POINT) and across from the town is the terminal where the oil is piped onto tankers (POINT). These are some tankers (POINT).

The tankers go through the narrows here (POINT) into Prince William Sound. The Exxon Valdez tanker went aground on an underwater reef about here (POINT).

This whole area (POINT) is Prince William Sound.

SHOW PHOTO B

The next photo shows a view of part of the Sound.

As you can see, it is ringed with high mountains. In many areas there are glaciers that break up and produce small icebergs. This photo shows the Columbia Glacier which is more than 100 feet high (POINT TO GLACIER WALL). Icebergs from this glacier sometimes float into the shipping lanes.

SHOW PHOTO C

As you can see in the next photo, the area is largely undeveloped.

Most of the land has been set aside as national forest and state parks. People use the area for fishing, boating, camping and other recreation. In the whole area there are only a few small towns. (PAUSE)

BOX B

During the period of the spill there were about one and a half million seabirds and sea ducks of various species in the spill area inside and outside Prince William Sound. (POINT)

As you can see from this card, 22,600 dead birds were found. (POINT)

The *actual* number of birds killed by the oil was larger because not all the bodies were recovered. Scientists estimate that the total number of birds killed by the spill was between 75,000 and 150,000.

About *three-fourths* of the dead birds found were *murres*, the black and white bird I showed you earlier. This is shown on the first line of the card. (POINT)

Because an estimated 350,000 murres live in the spill area, this death toll, though high, does *not* threaten the species.

One hundred of the area's approximately 5,000 bald eagles were also found dead from the oil.

The spill did *not* threaten any of the Alaskan bird species, including the eagles, with extinction. (PAUSE)

Bird populations occasionally suffer large losses from disease or other natural causes. Based on *this* experience, scientists expect the populations of all these Alaskan birds to recover within 3 to 5 years after the spill. (PAUSE)

Escort ship plan to prevent the next oil spill

- escort ship program would prevent and/or contain such a spill.
- Respondents were told that if the program were put into effect, two large Coast Guard ships would escort each tanker throughout its journey in Prince William Sound. The escort ships would help prevent an accident and, if an accident occurred, they would keep a very large spill from spreading beyond the tanker.
- It was important that the program be perceived as feasible, effective, and requiring the amount of money later stated as the cost the household would pay if it was approved in the referendum.

Valuation question

- Respondents were informed that the program would be funded by a one-time tax on the oil companies that take oil out of Alaska and that households like theirs would also pay a special one-time federal tax that would go into a Prince William Sound Protection Fund
- Immediately before asking the WTP questions, the interviewer presented the material shown in Box C, which was intended to reassure respondents who might not be willing to pay for the program that a no vote was socially acceptable.

BOX C

A-14E. Because everyone would bear *part* of the cost, we are using this survey to ask people how they would vote if they had the chance to vote on the program.

We have found some people would vote *for* the program and others would vote *against* it. Both have good reasons for why they would vote that way.

Those who vote *for* say it is worth money to them to prevent the damage from another large spill in Prince William Sound.

Those who vote *against* mention concerns like the following.

Some mention that it won't protect any other part of the country except the area around Prince William Sound.

Some say that if they pay for this program they would have less money to use for other things that are more important to them.

And some say the money they would have to pay for the program is more than they can afford.

Willingness to pay to prevent another Exxon Valdez type oil spill

Table IV. Questionnaire version by type of response

Version	Yes-Yes	Yes-No	No-Yes	No-No
A ($10, $30, $5)	45.08%	22.35%	3.03%	29.55%
B (30, 10, 60)	26.04%	26.04%	11.32%	36.60%
C (60, 120, 30)	21.26%	29.13%	9.84%	39.76%
D (120, 250, 60)	13.62%	20.62%	11.67%	54.09%

Results

- Estimated a $30 dollar (median) and a $97 dollar (mean).

- The original study reported an estimate of $2.8 billion (1990) dollars as the lower bound on the estimated aggregate lost values. This estimate was obtained by multiplying the number of English-speaking households (90,838,000 Census 1990), the population sampled, by the estimate of median WTP.

- In 1994, a jury awarded plaintiffs US$287 million in compensatory damages and US$5 billion in punitive damages.
- Exxon appealed and the Ninth Circuit court reduced the punitive damages to US$2.5 billion.
- Exxon then appealed the punitive damages to the Supreme Court which capped the damages to US$507.5 million in June, 2008.
- On August 27, 2008, Exxon Mobil agreed to pay 75% of the US$507.5 million damages
- In June 2009, a federal ruling ordered Exxon to pay an additional US$480 million in interest on their delayed punitive damage awards.

Valuing the willingness to pay for environmental conservation and management: A case study of scuba diving levies in Moo Koh Similan Islands Marine National Park, Thailand

SORADA TAPSUWAN

School of Economics, University of Queensland, St. Lucia, Queensland 4072, Australia.

"According to Thai regulations, you will be charged a diving fee to dive in Similan Islands. Are you willing to pay 200 baht/day to dive in Similan Islands?".

Table 1 Alternative Bids or Scuba Diving Fee Levels for the DCCVM Questionnaire (in Thai Baht)

BID	BIDL	BIDH
200	100	400
600	400	1200
1000	600	2000
1500	800	2500
2000	1500	3000

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Table 8 Estimates of WTP (Thai Baht ('00)/year) from the Single- and Double-Bound DCCVM

WTP	Single-bounded			Double-bounded		
	Combined (Model 1)	Overseas (Model 2)	Thais (Model 3)	Combined (Model 1)	Overseas (Model 2)	Thais (Model 3)
Mean	26.0617	26.7049	18.3055	11.2562	11.4604	10.7233
Median	8.5662	9.6540	5.7339	5.6143	7.4923	-2.8921

- Willingness to pay estimates from the double-bounded models were THB 1,017 (US$24.45) for Thai divers, THB 1,146 (US $27.55) for overseas divers and THB 1,125(US $27.05) for Thais and overseas divers combined.
- All these figures are much higher than the currently charged scuba diving fee level of THB 200 (US $4.8) per day (Thais and overseas divers are charged the same rate).
- Using estimated WTP from the double-bounded model, one can estimate the economic value of Moo Koh Similan Islands Marine National Park based on the total number of visitors to the park each year, averaged over 5 years from 1999-2003, which was 34,464.2, and mean WTP from the combined model (model 4), the economic value would be US $932,520 per year.
- If scuba diving fee charges were increased to THB 1,125 (US $27.04), which was the mean willingness-to-pay level found in the study, Moo Koh Similan Island Marine National Park would have an economic gain of THB 38,793,592 (US $932,520) per year

The Benefits of Reducing Gun Violence: Evidence from Contingent-Valuation Survey Data*

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Abstract

This article presents an estimate of the benefits of reducing crime using the contingent-valuation (CV) method. We focus on gun violence, a crime of growing policy concern in America. Our data come from a national survey in which we ask respondents referendum-type questions that elicit their willingness-to-pay (WTP) to reduce gun violence by 30%. We estimate that the public's WTP to reduce gun assaults by 30% equals $24.5 billion, or around $1.2 million per injury. Our estimate implies a statistical value of life that is quite consistent with those derived from other methods.

The 1998 National Gun Policy Survey (NGPS) is a nationally representative telephone survey of 1,204 American adults conducted during the Fall of 1998 by the National Opinion Research Center (NORC) at the University of Chicago. Interviews were conducted with one adult per sampled household, with the adult chosen randomly via the most-recent-birthday method. The response rate for the NGPS was 61% (see Kuby, Imhof, and Shin, 1999).

After a series of questions asking about their attitudes towards government and various current or proposed gun regulations, respondents are asked the following questions: "Suppose that you were asked to vote for or against a new program in your state to reduce gun thefts and illegal gun dealers. This program would make it more difficult for criminals and delinquents to obtain guns. It would reduce gun injuries by about 30%, but taxes would have to be increased to pay for it. If it would cost you an extra [$50/$100/$200] in annual taxes would you vote for or against this new program?" The amount of the tax increase that the respondent is asked about, either $50, $100 or $200, is randomly determined by the survey software. Respondents are then asked a follow-up where the dollar amount asked about in the initial referendum question is either doubled or halved, depending on whether the respondent's initial answer was positive or negative, respectively.

Table 4. Maximum likelihood estimates for WTP to reduce gun assaults by 30%, from NGPS data

	Without covariates	With covariates[a]
Estimated WTP to reduce GSW by 30%		
Mean	$203	$239
(95% confidence interval)	(185–220)	(103–375)
Median	$203	$204
(95% confidence interval)	(185–220)	(68–340)
Estimated societal WTP for program to reduce gun assaults by 30%[b]	$20.8 billion	$24.5 billion

[b]Obtained by multiplying mean WTP per household by number of households in the United States in 1998, which is equal to 102.5 million (U.S. Bureau of the Census, 1999a,b).

Singapore's willingness to pay for mitigation of transboundary forest-fire haze from Indonesia

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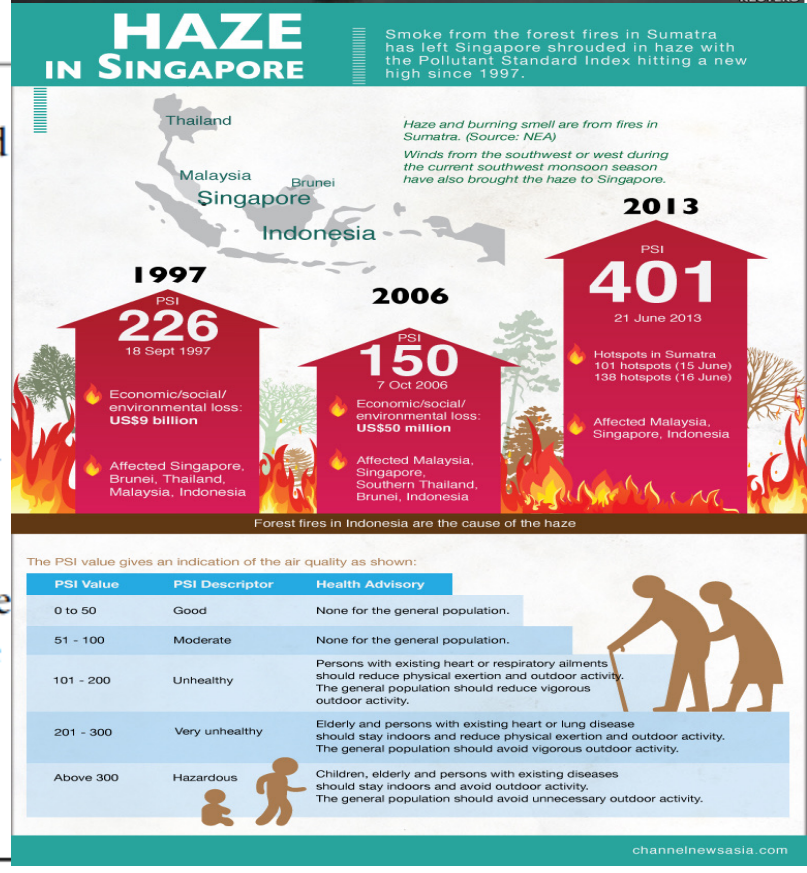
Keywords: willingness to pay, haze, Indonesian forest fires, peatlands, contingent valuation

Abstract

Haze pollution over the past four decades in Southeast Asia is mainly a result of forest and peatland fires in Indonesia. The economic impacts of haze include adverse health effects and disruption to transport and tourism. Previous studies have used a variety of approaches to assess the economic impacts of haze and the forest fires more generally. But no study has used contingent valuation to assess non-market impacts of haze on individuals. Here we apply contingent valuation to estimate impacts of haze on Singapore, one of most severely affected countries. We used a double-bounded dichotomous-choice survey design and the Kaplan-Meier-Turnbull method to infer the distribution of Singaporeans' willingness to pay (WTP) for haze mitigation. Our estimate of mean individual WTP was 0.97% of annual income ($n = 390$). To calculate total national WTP, we stratified by income, the demographic variable most strongly related to individual WTP. The total WTP estimate was $643.5 million per year (95% CI [$527.7 million, $765.0 million]). This estimate is comparable in magnitude to previously estimated impacts of Indonesia's fires and also to the estimated costs of peatland protection and restoration. We recommend that our results be incorporated into future cost–benefit analyses of the fires and mitigation strategies.



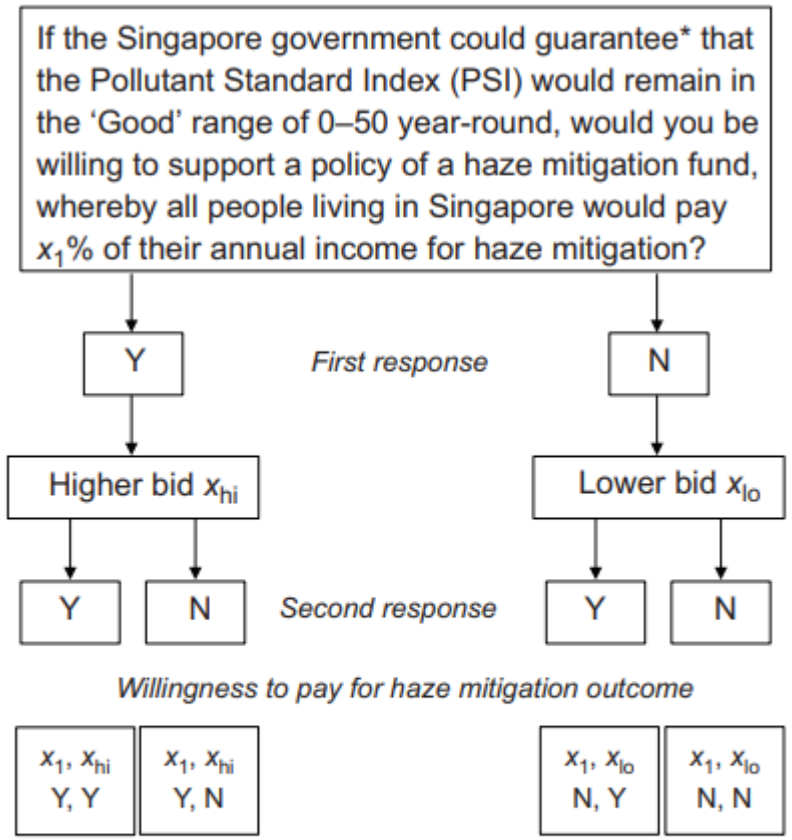


Figure 1. A flowchart of the double-bounded dichotomous choice survey used. The bid values x_1 and x_{hi} and x_{lo} were varied across surveys (see text). *Respondents were informed, 'For the purposes of this survey, assume that this policy is feasible, regardless of any personal doubts you might have.'

Table 1. Six sets of bidding values used in the survey.

	1	2	3	4	5	6
First bid (x_1)	0.10%	0.25%	0.50%	1.00%	2.00%	4.00%
Second bid (x_{hi})	0.25%	0.50%	1.00%	2.00%	4.00%	5.00%
Second bid (x_{lo})	0.05%	0.10%	0.25%	0.50%	1.00%	2.00%

- Approach the k^{th} passerby, where k is a random integer between 1 and 10 drawn independently for each survey.
- Obtain verbal consent from the respondent prior to the survey.
- Present the respondent with a short introductory paragraph briefly summarizing the haze situation in Singapore and its health and economic impacts.

$$\mathrm{WTP} = \sum_{i=1}^{k} I_i w_i N_i$$

- I_i is the median income for income bracket i
- w_i is the percentage WTP for income bracket i
- N_i is the number of working Singapore residents in income bracket i

Table 3. Estimation of total WTP from onsite surveys stratifying by income levels (all dollar figures in SGD).

Monthly income (SGD)	Median monthly income (SGD)[a]	Number of working residents (thousands)	Estimated percentage WTP	Estimated total annual WTP (SGD)
Under 500	250	47.0	1.20%	1.7 m
500–999	750	125.9	1.20%	13.5 m
1 000–1 499	1 250	234.5	1.20%	42.1 m
1 500–1 999	1 750	203.9	1.20%	51.2 m
2 000–2 499	2 250	205.8	1.09%	60.5 m
2 500–2 999	2 750	164.3	1.09%	59.0 m
3 000–3 999	3 500	294.4	1.09%	134.5 m
4 000–4 999	4 500	194.7	0.85%	89.4 m
5 000–5 999	5 500	157.2	0.85%	88.2 m
6 000–6 999	6 500	94.8	0.58%	43.1 m
7 000–7 999	7 500	72.2	0.58%	37.8 m
8 000–8 999	8 500	59.1	0.58%	34.9 m
9 000–9 999	9 500	40.0	0.58%	26.4 m
10 000–10 999	10 500	40.7	0.70%	35.9 m
11 000–11 999	11 500	23.7	0.70%	22.9 m
≥12 000	12 000	139.5	0.70%	140.5 m
Estimated total national annual WTP (SGD)				**881.6 m**
Estimated total national annual WTP ($)				**$648.2 m**

Results

- Our estimate of total WTP for the whole of Singapore, based on the onsite responses and stratifying by income brackets, was $648.2 million per year
- A preliminary crude estimate of $1.8 billion for regional annual WTP can be obtained by scaling up our estimate for Singapore by the ratio of GDP of nearby haze-affected regions (GDP of Singapore, Malaysia, and Indonesian provinces in Sumatera, Kalimantan and nearby islands) to Singapore's GDP.➔ using benefit transfer method.

Caveats

- positive bias may arise from the fact that our surveys were (by happenstance rather than design) carried out shortly after the 2015 haze event— one of the worst such episodes in Singapore's history.
- there are particular groups that were difficult to include, such as people with a little education background and high-income earners.
- Not include impacts on tourism industry.