Expertise and Legitimacy:
The Role of Science in Global Environmental Policy-Making

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Carbon emissions

This thesis, which generated about six tonnes of carbon dioxide from flights, paper production, printing, heating, and electricity usage has been carbon-neutralized through NativeEnergy. This was done by capturing methane from an American farm.

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A note about the typeface

This thesis is set in Eric Gill's Perpetua, as released by the Monotype Corporation between 1925 and 1932. Perpetua is named for the book in which it was first used: *The Passion of Perpetua and Felicity.*

For my grandparents

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Acronyms and abbreviations

AMAP: Arctic Monitoring and Assessment Programme
CLRTAP: Convention on Long-range Transboundary Air Pollution
EPA: Environmental Protection Agency (United States)
IPCC: Intergovernmental Panel on Climate Change
INAC: Indian and Northern Affairs Canada
NCP: Northern Contaminants Program
POP: Persistent organic pollutant
UNECE: United Nations Economic Commission for Europe
UNEP: United Nations Environment Programme

Note: for a more comprehensive list of acronyms, see the following website: http://www.sindark.com/wiki/index.php?title=Appendix_I:_Glossary_and_Table_of_Acronyms

Chapter 1: Introduction

In the modern era, science has become the preferred mechanism for generating and deepening understandings of what is happening in the world: a role that has become critical as policy-makers worldwide have been confronted with environmental problems of unprecedented complexity. The scale of human industrial and agricultural activity has become such that the global environment is being impacted to an extent that could scarcely have been imagined a century ago. In response, not only must traditionally political matters like interests and ideologies be addressed[1], but policy makers must also interact with the scientific community in a dynamic and effective matter. Between scientists, policy-makers, and other actors, policies must be developed that can effect desired changes, while developing and maintaining the political support required to do so legitimately. Approaches that combine the values of expertise and legitimacy provide the intellectual and normative foundations for effective policy development.

The Stockholm Convention on Persistent Organic Pollutants[2] and the Kyoto Protocol to the United Nations Framework Convention on Climate Change[3] demonstrate some of the fundamental characteristics of the increasingly important relationship between science and policy.[4] The Stockholm Convention addresses the production and usage of certain harmful chemicals known as Persistent Organic Pollutants (POPs), while the Kyoto Protocol is an attempt to address the problem of climate

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[1] A collection of essays on the various responses political theorists have written to the 'ecological challenge' can be found in: Andrew Dobson and Robyn Eckersley, Political Theory and the Ecological Challenge (Cambridge: Cambridge University Press, 2006).

[2] The Stockholm Convention on Persistent Organic Pollutants was opened for signature May 23rd, 2001 and entered into force May 17th, 2004 with 128 parties and 151 signatories.

[3] The Kyoto Protocol to the United Nations Framework Convention on Climate Change was opened for signature December 11th, 1997 and entered into force February 16th, 2005 with 55 parties representing more than 55% of CO2 emissions by Annex I states.

[4] Hereafter, the agreements will be called simply 'the Stockholm Convention' and 'the Kyoto Protocol.'

change through the regulation of greenhouse gas (GHG) emissions. Each environmental 'problem' is a novel one – unanticipated until a few decades ago – and each deals with transboundary activities and outcomes.[5] In terms of the environmental impact of contemporary economic activity, globalization has produced its most acute challenge to the idea of firm boundaries between states. Climate change and POPs are both chemical phenomena that pay no heed to political boundaries. At the same time, both cases include complex political situations involving multiple actors and jurisdictions. Through these cases, the practical and normative implications of the relationship of science and policy can be investigated. Science doesn't merely inform as to what is or is not possible - it helps to shape normative conceptions about the nature of 'nature' itself, and the basis of the human relationship with it and with one another.[6] Through better understanding of the science-policy relationship, more normatively aware and pragmatically realizable approaches to global environmental policy-making may emerge.

Purpose

This examination has two major purposes: to examine the Stockholm Convention and the Kyoto Protocol as important examples of science based policy-making, and to investigate the most important points of contact between science and international politics. The issues of POPs and global climate change are important in and of themselves, as well as insofar as they are examples of the kind of global issues likely to become more common as the global population, economic production, and resource usage continue to increase. The scale and importance of environmental issues are such that they could

[5] Note that the placement of 'problem' in single quotes indicates that the term has not yet been adequately defined in this thesis, not that climate change and POPs cannot be reasonably categorized that way.

[6] See the section entitled "Scientists in society" in chapter four for more extensive discussion of the role of scientists in generating such 'big ideas' about the nature of the world.

disrupt existing patterns of economic and political organization. As such, they are of special concern to those studying the nature and evolution of the international system.

Understanding the environment requires expertise from many fields: encompassing everything from atmospheric science to the study of international legal regimes. As such, hundreds of scholars in dozens of disciplines have engaged with the central questions of this thesis. Elements of the classical international relations (IR) literature contribute valuable insights, especially on questions of coordination and bargaining. An important example is the development of mechanisms to avoid free riding in the design of cost-sharing systems, as both the Kyoto Protocol and Stockholm Convention have attempted. Identifying those areas where IR scholars can profitably engage with other disciplines will help to situate global environmental politics within the discipline of IR, and the discipline of IR within the broader collection of scholars and scientists concerned with the environment.

While this thesis will attempt to draw important connections between different areas of academic study, it is not possible to draw all possible connections between all relevant literatures. For instance, while the philosophy of science is clearly relevant to this examination, it will not be a primary focus, for reasons of space and expertise. Likewise, detailed histories of the negotiations leading to the Stockholm Convention or the Kyoto Protocol exceed the scope of what can be included here.[7] The treatment of those very intricate progressions will be quite selective, focusing on the elements more relevant to the questions being asked. Also, while the perceptions of third parties (especially the citizens of the states that are party to both conventions) are clearly an interesting object

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[7] The best such histories are probably the following:
POPs: T. Fenge, David Leonard Downie and Inuit Circumpolar Conference., Northern Lights against Pops : Combatting Threats in the Arctic (Montreal ; Ithaca: Published for the Inuit Circumpolar Conference Canada by McGill-Queen's University Press, 2003).
Climate change: Spencer R. Weart, The Discovery of Global Warming, New Histories of Science, Technology, and Medicine (Cambridge, Mass.: Harvard University Press, 2003).

for social scientific study, they do not fall within the bounds of what will be extensively discussed in this thesis. That said, the importance of the science-policy relationship to general perceptions about the legitimacy of governments, international regimes, and intergovernmental organizations would be a valuable extension of this analysis. By acting as a knowledge broker, the media is an essential regulator of these relationships.

The global politics of the environment

The formulation of equitable and effective environmental policy requires that policy-makers be guided both by expertise about the physical nature of the world and about the political ideas and structures of political organization that constrain and direct those within it. Understanding of science and politics is necessary both for making sense of what has transpired in the past and for developing effective future models of cooperation and management.

The longstanding focus of IR on problems of coordination within non-hierarchical systems is clearly relevant to the formulation if international policy on the environment. Whether one's objective is disarmament, the maintenance of global economic and financial stability, or the tackling of global warming, there is a need for institutions and mechanisms through which states can communicate, agree, and engage in cooperative action.[8] At the same time, there must be mechanisms to ensure that compliance with agreed norms, rules, and laws is not ephemeral, ceasing at the moment where it becomes inconvenient to the burdened party. While some scholars of IR have generally despaired of the capability of states to operate cooperatively, the insights of the discipline into the actual and potential interactions of states pertain to this research area quite forcefully. Only through an understanding of what is possible and why can effective action be organized. Studies of bureaucratic politics and game

[8] Such an institutionalist viewpoint is perhaps most justified in the area of environmental politics, given how the border-transpiring properties of environmental problems requires coordination between jurisdictions.

theory are perhaps especially capable of revealing important properties of joint decision-making processes. While states remain the key agents in the formulation and application of environmental politics, the environmental sphere is an area within IR where the role of non-state actors must be given serious consideration. This is true both in raw power terms – as transnational corporations have acquired phenomenal abilities to alter the global environment – and in ideational and discursive terms – as non-governmental organizations have increasingly found a role as 'knowledge brokers' situated between those generating specialist knowledge about the world and those who apply it to reaching consensus and establishing policy responses.[9]

As a political discipline, IR can also access the normative issues inherent to environmental policy-making in a useful way. A great body of normative theory has arisen about the obligations that exist between citizens of different states, as well as between those alive in the present day and generations to follow.[10] Such theory is important from the perspective of pursuing greater global justice and on the much more pragmatic grounds that discussion of moral consequences is frequently a pre-requisite to effective agreement. The perception of fairness and meaningful representation has value in generating and maintaining cooperation.[11] The situation of India and China, with regards to the pursuit of development and global concerns about climate change, is a case in point. Only through mechanisms that address the connected problems of development, poverty, and environmental protection can durable compromises be struck and effective responses to environmental problems be generated.

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[9] Lindsay Johnson, "Advocates, Experts or Collaborative Epistemic Communities? Defining the Scientific Role of Ngos in International Environmental Negotiations," University of British Columbia, 2006.

[10] Responsibility to future generations has also been embedded, to some extent, in key judgments and treaties in international law, such as the advisory opinion of the International Court of Justice on the legality of nuclear weapons. Intergenerational justice is likewise a key feature in debates about the ethics of climate change.

[11] See: "Who participates in consensus formation?" in chapter three.

Both domestic and international politics have long involved the delegation of authority to expert groups. On many levels, the process of delegating some responsibility for environmental policy to experts in the field is not enormously different from delegating responsibility for international negotiations to diplomats, the conduct of warfare to professional militaries, or the control of macroeconomic policy to economists in an independent central bank. All these delegations involve the recognition that policy-makers lack the time and training to engage directly with some of the specifics of policy development in technical areas. What is unique about the relationship between science and policy is the exceptionally privileged role granted to science as the principal human mechanism for gaining understanding about the world. The new capabilities granted to humanity through the application of scientific knowledge are one major explanation for that influence. At the same time, profound disagreement exists about the appropriate role of scientists in areas that require both technical mastery and the consideration of other factors for which their training provides no special qualification.

Longstanding engagement between the study of international relations and expert groups has created useful tools for understanding why the situation as regards the environment is both similar and distinctive. One major contribution has been the work of Haas on epistemic communities,[12] as well as the consideration of the role of ideas in theories of international cooperation.[13] The greatest similarities between the role of expertise in the environmental context and in other areas – such as warfare or economics – lies in the construction of social roles within expert communities, on the basis of shared procedures and understandings. The greatest differences probably lie in the breadth of what can be

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[12] See: Peter Haas, "Do Regimes Matter? Epistemic Communities and Mediterranean Pollution Contol," International Organization 43.3 (1989).

[13] Haas, Peter. “Epistemic Communities and the Dynamics of International Environmental Cooperation.” In V. Rittberger, Regime Theory and International Relations (Oxford: Oxford University Press, 1993).
Peter Haas, "Introduction: Epistemic Communities and International Policy Coordination," International Organization 46.1 (1992).

called 'environmental issues.' That lack of specificity makes the international environmental community more amorphous and indistinct than the examples listed above, with consequences for how membership is understood, what kind of consensus can exist, and the form of engagement between that community and those of policy-makers.

Case studies

The two case studies – the Stockholm Convention and Kyoto Protocol – contribute to the study of science-based policy-making on the basis of their inherent importance and comparative potential. The biological effects of POPs threaten the quality of many human lives around the world, while global climate change could produce truly appalling consequences if emissions go unchecked and some contemporary hypotheses prove valid.[14] Both the emergence of POPs and climate change were unanticipated products of human activity: specifically global industrialization, the widespread adoption of certain technologies, and massive population growth. As such, they provided new targets for scientific inquiry and political discourse. In terms of their success at developing political consensus on the need for action and the scope of the underlying problem, Stockholm and Kyoto differ a great deal. Likewise, they differ on the extent to which they would, even if fully implemented, actually address the underlying problem. Partially, this can be explained by the vastly different scales of cost and complexity involved in the two issues. Chapters two through four will include far more extensive consideration of the similarities and dissimilarities between the two situations. Due to the relative familiarity of the climate change issue, this initial discussion of the background to the case studies will put more weight on the Stockholm Convention and the scientific work leading up to it.

[14] This is particularly true of runaway climate change scenarios based on positive feedback cycles involving methane deposits in the far north or under the sea. Less potentially catastrophic, but dynamically similar, is the prospect of a feedback loop between the melting of Arctic ice, the reduction of the reflective property of the region with respect to sunlight, temperature rise, and further melting.

Background to the POPs issue

Early indications of high and unexpected concentrations of POPs in the blood and breast milk of individuals living in the Arctic prompted a large-scale scientific inquiry called the Northern Contaminants Program (NCP), orchestrated by the Indian and Northern Affairs Canada (INAC).[15] While concerns about the biochemical effects of POPs date back to the 1960s, the first noted discovery of unexplained high concentrations in Arctic native populations were made in 1985.[16] The discovery prompted the creation of the NCP: a research program conducted over six years, organized by INAC and largely conducted by volunteers. The participation of the Inuit Circumpolar Conference (ICC) in the NCP process is notable, insofar as it provided a direct mechanism for the stakeholders most directly impacted by the POPs issue to access the process of scientific investigation and, later, political negotiation. The NCP developed the existing scientific understanding of the so-called 'Grasshopper effect' whereby POPs are transmitted long distances due to their evaporative properties in the atmosphere.[17] Also studied were the biological impacts of POPs upon the human population, and the impacts of POP contamination upon the lifestyles of Arctic native peoples.[18] It is notable that while Artic native groups in the United States were similarly exposured, the American government left

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[15] See: B. Commoner, P. Bartlett, H. Eisl and K. Couchot, "The Link between Anthropogenic Sources of Dioxin and the Human Food Chain: Source-to-Receptor Air Transport," Halogenated environmental organic pollutants and POPs; Dioxin 2000, ed. M. S. Denison (Monterey, CA: Emmenzeta, 2000), vol.
J. Grigg, "Environmental Toxins; Their Impact on Children's Health," Archives of Disease in Childhood 89 (2004).

[16] Dewailly, Eric and Christopher Furgal. "POPs, the Environment, and Public Health." in Fenge, Downie and Inuit Circumpolar Conference., Northern Lights against Pops.

[17] Also known as Global Fractionation or Global Distillation: a process through which evaporation and precipitation cause POPs to circulate around the globe, as well as concentrate in the polar regions.
See: P. W. Bartlett, B. Commoner, K. Couchot, B. Bush, H. Eisl and P. Cooney, "Modeling Source-to-Receptor Atmospheric Transport: Atrazine, Pcbs and Dioxin in North America," Halogenated environmental organic pollutants and POPs; Dioxin 2000, ed. M. S. Denison (Monterey, CA: Emmenzeta, 2000), vol.

[18] This thesis will use the term 'Arctic native peoples' to denote all aboriginal groups living in the Arctic region, within Canada, the United States, and Russia. This collection is quite diverse. For instance, just the Canadian Arctic Indigenous Peoples Against POPs (CAIPAP) group involves the Inuit, Métis, Dene, and Yukon First Nations.

responsibility for investigating the problem with the normal environment ministry. Consequently, relatively little was done on an issue that impacted a relatively small number of people.[19] The POPs situation thus raises moral questions about utilitarian conceptions of environmental ethics, and the extent to which larger groups can be called upon to make sacrifices for the benefit of smaller but more profoundly threatened ones.

Both regional and global responses to the POPs issue were developed during the 1990s. On the basis of conclusions reached by NCP scientists, the United Nations Economic Commission for Europe (UNECE)[20] devised a regional mechanism meant to deal with POPs: the 1998 Convention on Long-range Transboundary Air Pollution (CLRTAP). While the two processes were not formally connected, the development of CLRTAP was concurrent with that leading to the Stockholm Convention. John Buccini, chair of the Stockholm negotiations, suggests that it was the work done on CLRTAP that created the general sense that "the time was right to pursue a global agreement on POPs." [21] The negotiations that led to the Stockholm Convention began in 1995, with the secretariat including personnel from the Intergovernmental Forum on Chemical Safety (IFCS), formed in 1994. On May 25th, 1995 the Governing Council of the UNEP called upon the IFCS, the Inter-Organization Programme for the Sound Management of Chemicals (IOMC), and the International Program on Chemical Safety (IPCS) to begin work on an "expeditious assessment process, initially beginning with twelve specific POPs." [22] From there began a complex process of negotiations (mentioned again in chapter two and

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[19] See: Huntington, Henry and Michelle Sparck. "POPs in Alaska: Engaging the USA." in Fenge, Downie and Inuit Circumpolar Conference., Northern Lights against Pops.

[20] UNECE is a regional commission established in 1947 to encourage economic cooperation between member states. It reports to the UN Economic and Social Council (ECOSOC) and includes the United States and Canada among its 56 members. For more information, see: <http://www.unece.org/>

[21] Buccini, John Anthony. "The Long and Winding Road to Stockholm: The View from the Chair." in Fenge, Downie and Inuit Circumpolar Conference., Northern Lights against Pops.

[22] Buccini, John Anthony. Ibid. p. 225

detailed in the Fenge and Downie volume) that led ultimately to the 2001 Stockholm Convention.[23] The enormous complexity of the evolution of this relatively minor environmental instrument foreshadows the intricacies of the process surrounding the Framework Convention on Climate Change.

The surprising ranges across which POPs can travel, and the variety of economic activities that generate them, effectively necessitate global involvement for an effective solution. Everything from the decay of the Distant Early Warning (DEW) line RADAR stations[24] in the Canadian Arctic to the burning of large quantities of garbage in Japan (generating dioxins and furans, two of the chemical types restricted by Stockholm) contributes to the accumulation of POPs in the environment; because they are not broken down inside the bodies of living things, they then further concentrate at successively higher levels of food webs, becoming most threatening at the concentrations they reach in key food animals consumed by Arctic native peoples. POPs also have health and environmental effects in the areas in which they are produced and released, a characteristic that probably helped in the development of the Stockholm Convention. Had the 150,000 people living in the Arctic been the only group impacted by POPs it seems unlikely that a global effort of the magnitude of the Stockholm Convention would have been made. In the end, the negotiation and implementation of Stockholm has created a reasonably effective global regime to address the so-called 'dirty dozen' most concerning POPs.[25] While the regime is imperfect and chemical threats continue to be presented to the human and animal inhabitants in the Arctic, the Stockholm Convention does represent an effective piece of international cooperation on a transboundary issue. Through internal mechanisms – especially the POPs Review

[23] Fenge, Downie and Inuit Circumpolar Conference., Northern Lights against Pops.

[24] In 1996, a $300 billion plan was conceived by the United States and Canada to address the problem of PCB leakage from the 63 RADAR stations in the DEW Line, originally built to detect Soviet bombers initiating an attack across the pole.

[25] See Appendix I for a listing.

Committee – it can also adapt to address changes in the scientific understanding of POP chemistry, or the development of new POP-like chemicals.

Background to climate change

Similarly, concerns about the existence and significance of anthoropogenic climate change prompted the creation of the largest scientific collaboration in human history: the Intergovenmental Panel on Climate Change (IPCC). It must be noted that the IPCC does not exist to conduct scientific research in its own capacity, but rather to examine the research that has been done and generate a broad consensus on the nature, origin, and probably magnitude of climate change. The IPCC was established in 1988 by the World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP) with the aim of evaluating the available technical, scientific, and socio-economic information about climate change. As such, the mandate of the IPCC is not exclusively scientific. To date, the IPCC has released three assessment reports (with the fourth in the process of publication). Released in 1990, 1995, and 2001, these are generally considered the most authoritative sources on the scientific and technical aspects of climate change.[26] It is reasonable to say that the IPCC has played the same role, for Kyoto, as the NCP did for Stockholm.

At the 1992 United Nations Conference on Environment and Development (UNCED), the parties negotiated the United Nations Framework Convention on Climate Change (UNFCCC): a non-binding treaty intended to begin the process of dealing with climate change. This opened for signature on May 9th, 1992 and entered into force on March 21st, 1994. While the UNFCCC established no mandatory limits upon emissions, it did establish the Annex I / Annex II division that persists in the Kyoto Protocol, separating developed from developing countries in terms of their status under the treaty and their responsibilities. It also mandated the creation of national registries of GHG emissions

[26] Full citations for the IPCC reports are in the bibliography.

and the reporting of those figures. Opened for signature on December 11th, 1997 the Kyoto Protocol to the UNFCCC establishes mandatory reductions of GHG emissions by Annex I (developed) countries. With the Russian ratification on November 4th, 2004, the Kyoto Protocol included parties representing more than 55% of CO2 emissions from Annex I countries and thus entered into force. Despite the binding targets, several states (including Canada) are not presently on track to achieve their agreed reductions.[27] Furthermore, the extent to which the Kyoto Protocol would address the issue of climate change even if fully implemented is limited. Full Kyoto implementation would not even stabilize world GHG levels, much less begin to reduce them towards pre-industrial levels. At best, the protocol can be seen as a step toward the development of a global climate change regime capable of mitigating anthropogenic climate change.

The case of Kyoto, in particular, demonstrates troubling limitations in both the existing methods of scientific inquiry and those of political decision making. Because the global environment cannot be easily explained by being broken into constituent parts, which can be individually examined using traditional techniques, it requires the further development of methods for evaluating complex systems in their entirety. Phenomena that do not conform well to reductionist evaluation are challenging to deal with on the basis of contemporary science, which generally solves problems by reducing them to individually testable components. Because of the long time horizons and level of uncertainty involved in making decisions about climate change, new political challenges arise as well, such as how to account for the interests of future generations who may have the nature and quality of their lives profoundly altered by present action or inaction. The political question of who bears the risks involved in climate change policy – whether of over-spending on a problem less significant than widely

[27] Former Canadian environment minister Rona Ambrose said: "it is impossible, impossible for Canada to reach its Kyoto targets." See: "'Impossible' for Canada to Reach Kyoto Targets: Ambrose," CBC News 7 April 2006. <http://www.cbc.ca/canada/story/2006/04/07/kyoto060407.html>

believed or of under-spending and thus suffering considerable damages from climate change – is likewise a fundamentally challenging one.

Related cases

Naturally, many of the important characteristics of the POPs and climate change issues are mirrored in the cases of other environmental problems. Perhaps foremost among those is the depletion of stratospheric ozone, caused by human emissions of CFCs.[28] In many ways, the 1987 Montreal Protocol on Substances That Deplete the Ozone Layer is a parallel case to that of the Stockholm Convention.[29] The practice of iteration in the development of environmental policy, as employed in both the Stockholm Convention and the UN Framework Convention on Climate Change, can be traced to the Montreal Protocol. The endorsement of the Montreal Protocol by former UN Secretary-General Kofi Annan as "[p]erhaps the single most successful international agreement to date" sheds some light on what constitutes an effective international remedy to a global environmental problem.[30]

Expertise and legitimacy

'Expertise' and 'legitimacy' can be defined in a number of ways; their usage here is intended to serve as an aid to discussion and analysis. As such, each is being assigned a specific meaning less exhaustive than the full range of connotations in normal language. The particular definitions chosen are widely used within various literatures, but intentionally do not capture the full range of interpretations that could be accorded to the term. They are thus meant to represent 'a particular thing that can sensibly be called legitimacy' rather than 'the totality of things to which the term legitimacy could be

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[28] Karen Litfin's Ozone Discourses is a very interesting examination of how science and politics interacted on the CFC issue.

[29] Opened for signature September 16th, 1987 and entered into force January 1st, 1989. It has since undergone five revisions: in London in 1990, Copenhagen in 1992, Vienna in 1995, in Montreal in 1997, and Beijing in 1999.

[30] "In Praise Of... The Ozone Layer," The Guardian 30 September 2006. <http://environment.guardian.co.uk/climatechange/story/0,,1884443,00.html>

sensibly attached.' The reasoning behind this choice is to set up a dialogue between the two as justifications for participation in the policy process, as well as areas of scholarly investigation.

'Expertise' is taken to mean the possession of skills that allow for a greater ability to understand the nature of the world, particularly in ways that allow it to be more effectively altered. The latter criterion is important because it distinguishes science – which ultimately allows for the development of new technologies – from endeavours like philosophy, which may yield greater understanding of the world but do not do so in ways that generate new ways of physically interacting with it. 'Legitimacy' is taken to mean the property of being seen as empowered to take decisions that impact others, on the basis of their active consent, a theoretically based political authority, or a combination of the two. Note that, in this conception, both a ruler whose power is justified through some notion of divine right and one who has been democratically elected are both engaged in policy-making by virtue of 'legitimacy.'

In brief, when asked to justify their seats at the negotiating table, those with expertise will do so with reference to what they can reveal about the world and how human beings can act within it; those with legitimacy will do so with reference to the people they are representing, the theory that justifies their right to make choices on behalf of others, and material demonstrations that their theoretical support is manifest in practice (for instance, through elections).

Thesis structure

Each of the three substantive chapters addresses a set of behaviours within environmental policy-making: problem investigation, consensus formation, and remedy design. These are differentiated by activity type, rather than chronological order. Indeed, they often take place in overlapping fashion, with developments in one area impacting the situation in others. Thus, this thesis explicitly rejects the idea that science turns to policy through a linear progression, in which each stage reaches some kind of conclusion before the next begins. [31] The substantive chapters begin by problematizing an important aspect of the science-policy relationship, then move through a discussion of the two case studies to a thematic examination of some key dimensions of each area of endeavour.

The three core chapters will grapple with the most interesting issue areas that come up when examining expertise and legitimacy in the formulation of environmental policy: (a) the ways in which individuals and groups deal with information presented to them by the world and by their own investigations, (b) the ways in which they interact so as to move from problem identification to policy formulation, and (c) the normative consequences of those policy actions. How, for instance, has the international scientific community become overwhelmingly convinced about the reality of climate change? How does that consensus migrate from the scientific to the political realm? And how does political consensus manifest itself in the international arena? Clearly, these questions are exceptionally broad, and it cannot be the purpose of this examination to provide comprehensive answers. Rather than taking on the impossible task of answering these questions exhaustively, the focus will be on using the tools and conceptual frameworks of IR to better understand the science-policy relationship.

Chapter two, on problem identification and investigation, focuses on the conditions under which an environmental ‘problem’ is first identified. Such ‘problems’ arise from a combination of facts about the world, ideas about causal linkages, and human preferences and aesthetics. The chapter then considers the process whereby such problems are investigated and categorized, with the Northern Contaminants Program (NCP) and Intergovernmental Panel on Climate Change (IPCC) as case studies. Thematically, the chapter considers the importance of warfare, politics, and culture to the development of the contemporary understanding of climate change. Also examined are the special role

[31] For a criticism of the linear model, see: Roger. A. Jr. Pielke, "When Scientists Politicize Science: Making Sense of Controversy over the Skeptical Environmentalist," Environmental Science and Policy 7.5 (2004).

of the Arctic as an area in which environmental problems often manifest themselves early, the importance of trust and judgment in problem identification, and the importance of iterated approaches in addressing environmental problems.

Chapter three, on consensus formation in science and politics, will examine the heuristic and logical mechanisms through which particular individuals and groups reach judgments about environmental issues. The chapter opens with an examination of the importance of uncertainty as both a technical, political, and normative phenomenon. The formation of consensus in the two case studies is examined, followed by a thematic examination of deliberation, prioritization, and social roles. In particular, this involves examining the relationship between scientific and political consensus, the issue of who participates in consensus formation, and the importance of social roles – particularly those of scientists.

Chapter four, on remedy design and implementation, begins with a theoretical consideration of the role of scientists in society. It then considers remedies that have been developed for the POPs and climate change problems: focusing on regional and global responses to POPs, the UNFCCC process and Kyoto Protocol, and touching upon the EU Emissions Trading Scheme. Thematically, the chapter then considers the relationship between science and economics, in the development of remedies to environmental problems, and the importance of scientists embedded in institutions: both in situations where they are called upon to serve highly specific functions and in those where they are given a broader remit to prioritize.

Central themes

Three overriding themes are entangled in the substantive chapters: the importance of social roles, the nature and consequences of uncertainty, and the ways in which processes entrench and conceal normative assumptions. These will be taken up at greater length in the conclusion.

Social roles are important, firstly, insofar as they help to establish the ways in which individuals will interpret information. Secondly, they help to shape normative conceptions of what constitutes appropriate or inappropriate behaviour, especially in terms of issues like advocacy and expertise. The idea of what it means to be a scientist helps to determine the boundaries of the scientific community, as well as the perceptions of both insiders and outsiders about which questions can be dealt with scientifically. Social roles also tie closely into considerations of legitimacy, insofar as they are a critical component in systems of oversight and supervision. The most contentious interactions between science and policy are those that take place in areas and on issues where the participation of scientists is not obviously privileged or justified.

Uncertainty is important both as a technical and an ethical phenomenon, because the means through which policy deals with uncertainty have moral consequences in terms of who ends up bearing risk and which moral claims are most effectively protected. Uncertainty is both a first and second order phenomenon: it can relate to the limits of our knowledge about elements of the world, and it can also relate to limitations that we perceive within our own models and approaches. The ways in which scientists and policy-makers describe and respond to uncertainty are thus central to consensus formation and remedy design, as well as playing their more obvious role in problem investigation.

In all three areas of examination, the processes through which things are achieved have considerable practical, political, and normative importance. This thesis challenges the idea that policy development in response to environmental problems can be a value-neutral or mechanical process, in the way sometimes described as the 'linear model' or the 'engineering perspective on science.' The normative elements in the design and operation of processes are important both in terms of how they shape outcomes and how they shape perceptions about the legitimacy and effectiveness of those programs and the organizations that design and implement them.

The fundamentally multi-disciplinary character of IR makes the discipline well placed to consider such junctures, where groups with very different approaches and forms of discourse interact in the international arena. An improved understanding of the relationship between science and politics may allow for a more refined understanding of the emergence of some of the most innovative and wide-ranging international regimes of the late twentieth century. Likewise, the reasonable prediction that environmental factors will play an important role in the global politics of the medium and near future suggests that such examination has a valuable role to play in the study of international politics.

Chapter 2: Problem identification and investigation

> "[The discovery of the ozone hole] was totally unexpected. We scientists are professional skeptics. We looked at it in an almost perverse sense, filled with joy about something new, something we could learn about. If it was predicted, we wouldn't have learned anything."
>
> -Richard Stolarski[1]

> "Research [is] a strenuous and devoted attempt to force nature into the conceptual boxes supplied by professional education."
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> -Thomas Kuhn[2]

Surprise has been an important element in the environmental politics of the twentieth and twenty-first centuries. Humanity has been exposed to the glaring reality that industry and agriculture on the present scale can have profound and unanticipated effects upon the natural environment: from the elimination of the Aral Sea, caused by Soviet Union redirecting the Amu and Syr Darya rivers to irrigate grain fields, or the creation of an ozone 'hole' over the Antarctic through the use of chemicals considered to be inert. This chapter examines two such surprises and the immediate responses they generated, particularly in the form of major scientific research projects. The first of those is the discovery of POPs in the Canadian far north, leading to major international investigations and eventually regulation. The second is the discovery of considerably increased levels of greenhouse gasses in the atmosphere, and various scientific attempts to comprehend the significance thereof. This chapter also considers the theoretical question of what an environmental 'problem' is, and what that reveals about the relationship between humanity and nature. This examination, and those in subsequent chapters on consensus formation and remedy design, also reveals some of the ways in which the processes of environmental policy-making diverge from the linear, rationalist conception of chronological succession

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[1] Atmospheric physicist working for NASA, interviewed by Karen Litfin. See: Karen Litfin, Ozone Discourses : Science and Politics in Global Environmental Cooperation, New Directions in World Politics (New York: Columbia University Press, 1994) 97.

[2] Thomas S. Kuhn, The Structure of Scientific Revolutions, 3rd ed. (Chicago ; London: University of Chicago Press, 1996) 5.

and a clear separation of fact and value based assessments.[3] As the two central, and frequently inter-linked, bases for meaningful participation in environmental negotiations, scientific expertise and political legitimacy combine and compete to direct outcomes.

One standard interpretation of the science-policy relationship holds that the two activities are separated chronologically, and not substantially enmeshed. In this view, scientists uncover the truth about the world, provide information to policy-makers, and give expert advice on possible policies. Policy-makers, by contrast, accept information from scientists and make decisions about allocations and approaches. This model is akin to that of engineering: engineers can tell politicians whether it is possible to build a bridge across a bay, what materials could be used, and what sort of costs to expect. Their evaluations are not largely conditioned by political factors and the political choice is not dictated by the information from engineers, except insofar as how impossible options are screened out. This model is faulty when applied to global environmental politics because it overlooks the complex ways in which science and politics interact. The very idea of an environmental 'problem' is complex one: involving considerations of fact, causal mechanisms, and preferences.

The psychological processes through which people develop and maintain understandings about the world contribute to the enmeshing of investigation, deliberation, and response design. So too do the nature of scientific investigation and the processes of political and moral deliberation. Existing factual and normative understandings can be subjected to shocks caused by either new data or new ideas. Changed understandings in one area of inquiry can prompt the identification of possible problems in

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[3] Schmid, Allan. "All Environmental Policy Instruments Require a Moral Choice as to Whose Interests Count." In Daniel W. Bromley and Jouni Paavola, Economics, Ethics, and Environmental Policy : Contested Choices (Oxford: Blackwell Publishers, 2002) 133-47.
Steven F. Bernstein, The Compromise of Liberal Environmentalism (New York: Columbia University Press, 2001).
Litfin, Ozone Discourses 11.

another. Finally, the processes and characteristics of problem investigation are conditioned by heuristic, political, and bureaucratic factors. The POP and climate change cases help demonstrate how scientific investigation is extensively conditioned by the political and social climate that prevails. Common themes emerge from the two case studies, including the special role of the Arctic, the importance of trust and judgment, and the utility of iterated approaches.

Defining environmental 'problems'

The identification of an environmental 'problem' is not a single crystalline moment of transition, from ignorance to understanding. Rather, it is ambiguous, contingent, and dependent upon the roles and modes of thinking of the actors involved, as well as values that inform judgments. Rather like Thomas Kuhn's example about the discovery of oxygen (with different people accessing different aspects of the element's nature, and understanding it in different contexts)[4], the emergence of what is perceived as a new environmental problem occurs at the confluence of facts, roles, and existing understandings. While one or more causal connections ultimately form the core of how an environmental problem is understood, they are given comprehensibility and salience as the result of factors that are not strictly rational. From the perspective of global environmental politics and international relations, environmental problems are best understood as complexes of facts and judgments: human understandings that are subjective and dynamic, despite how elements of their composition collide with the ontological realities of the world.

[4] Kuhn, The Structure of Scientific Revolutions 53.

Case study problems

Consider first the case of persistent organic pollutants (POPs). The toxicity of chemicals like dioxins was known well before any of the key events that led to the Stockholm Convention.[5] At the time, the problem of POPs was largely understood as one of local contamination by direct application or short distance dispersal. It took the combination of the observation of these chemicals in an unexpected place, the development of an explanation for how this had transpired, and a set of moral judgments about acceptable and unacceptable human conduct to form the present characterization of the problem.[6] That understanding in turn formed the basis for political action, the generation of international law, and the investigation of techniques and technologies for mitigating the problem as now understood. Science is not, therefore, an isolated activity prior to political deliberation. As Karen Litfin explains: “As political problems have become increasingly entwined with questions of scientific evidence and proof, the ability to interpret reality has itself become a major source of political power.” [7] Considering the final Stockholm Convention, the specific chemicals chosen and the particular individuals whose interests are best represented are the product of political and bureaucratic factors, both intertwined with the actions and representations of scientific inquiry. Similar concerns apply to ongoing debates about how to respond to climate change.

If we accept the history of climate change presented by former American Vice President Al Gore, the method of problem identification is especially notable. He asserts that the initial concern arose from the discovery of rising atmospheric CO2 concentrations by Roger Revelle in the 1960s,

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[5] Note that the United States banned DDT in 1972.

[6] Litfin highlights how causal and normative beliefs are analytically distinct, in the context of environmental policy: Litfin, Ozone Discourses 185.

[7] Litfin, Ozone Discourses 8.

rather than any direct observation of specific changes to the global climatic system.[8] This is akin to how the 1974 paper by Mario Molina and F.S. Rowland established the chemical basis for stratospheric ozone depletion by CFCs which then led to considerable political and regulatory action before their supposition was empirically confirmed.[9] Acting on such a basis demonstrates faith in both the empirical facts that have been observed and the theories about causal interactions that have emerged to explain their relationships. Gore's characterization of the initial discovery of the climate change problem also offers glimpses into some of the heuristic mechanisms people use to evaluate key information: deciding which arguments, individuals, and organizations are trustworthy and then prioritizing ideas and actions. The sources from which information is received are critical for determining how credible it will be considered, though the degree to which one or another organization is seen as credible may have more to do with ideological compatibility than with any kind of objective scrutiny. The mechanisms through which individual and group judgments are reached will be the major focus of chapter three.

Initial implications

The relationship between human understandings, preferences, and ideas about the nature of the world establishes the subjective character of environmental problems. Environmental 'problems' are here defined as the unwanted (though not necessarily unanticipated) side effects of human activity in the world.[10] While mining may release heavy metals into the natural environment, this did not crystallize in the minds of people as a problem until the harm they caused to human beings and valued biological

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[8] Albert Gore, An Inconvenient Truth : The Planetary Emergency of Global Warming and What We Can Do About It (London: Bloomsbury, 2006) 30.
Also described in: Spencer R. Weart, The Discovery of Global Warming, New Histories of Science, Technology, and Medicine (Cambridge, Mass.: Harvard University Press, 2003) 142.

[9] Mario and F Sherwood Rowland Molina, "Stratospheric Sink for Chlorofluoromethanes: Chlorine Atomic-Atalysed Destruction of Ozone," Nature 249 (1974).

[10] Undesirable features of nature, such as lightning storms, are not characterized as environmental problems precisely because their origin is not anthropogenic.

systems proved evident. While the ontological reality of heavy metal buildup preceded human understanding of the phenomenon, it could not be understood as an environmental problem at that time. It only became so through the confluence of facts about the world, a causal understanding between actions and outcomes, and moral and preferential judgments about what is right or desirable. Notably, human activity can both generate entirely new problems (such as POP toxicity), or it can worsen existing adverse conditions in nature, such as hurricanes. In both cases, the triple confluence described above is at work.

Two characteristics of a phenomenon are relevant to its status as an environmental problem: the degree to which the dynamics of the situation are understood, and the degree to which the change conforms to or deviates from preferences and understandings about appropriate ways to act.[11] As such, the status of a phenomenon as an environmental problem may be contested. There may be a conflict between sets of preferences: the alleviation of one environmental problem, for instance by regulating the usage of DDT, may reduce the scope to which another problem can be addressed, such as the increased prevalence of malaria in a warmer world. It is also possible that different groups of people could ascribe different value judgments to the same empirical phenomena. For instance, ranchers and conservationists disagree about whether or not it is desirable to have wolves in the countryside.

Examining the subjectivity of environmental problems does not simply add complexity to the discussion. It generates possibilities for a more nuanced understanding of the real and ideal relationship between human beings and nature (including perceptions about why the two are so often seen as distinct). Examining the subjective influences on such judgments allows the transcendence of the simplistic view of science as a neutral, empirical exercise in fact gathering. While less parsimonious

[11] Another factor relevant to normative evaluations is the degree to which the action producing the change is intentional. It is also likely that those who engage in activities that could plausibly have a major environmental impact have a duty to investigate the possible consequences of their actions.

approaches, such as the discourse analysis of Litfin and Maarten Hajer, cannot yield conclusions that are easily generalizable across issue areas, they can provide the kind of nuanced understanding that is necessary for effective and legitimate political action in the face of problems of an unprecedented nature and complexity.[12]

Identifying and investigating the POPs problem

1962	Rachel Carson's Silent Spring published
1966	PCBs first discovered in Baltic fish
1985	Kinloch and Kuhnlein studies identify high levels of POPs and metals in Arctic people and animals
1989	Eric Dewailly study reveals high levels of POPs in blood and breast milk of Inuit women

While the toxicity of POPs has been known essentially since their use began, important characteristics of their atmospheric and biological properties were only uncovered during the 1980s. In particular, the paths they take through food webs and their patterns of atmospheric distribution came to be better understood. That changed understanding was essential for the evolution of the political will to restrict POP usage and production, as eventually occurred through national and regional regulations (especially the Arhus Protocol to the Convention on Long-Range Transboundary Air Pollution), eventually culminating globally in the Stockholm Convention.

Bioaccumulation: POPs in living things

When first deployed, Dichloro-Diphenyl-Trichloroethane (DDT) was seen as a great tool for the improvement of human life. A potent pesticide, it eliminates crop-eating insects as well as the *Anopheles* mosquitoes that carry malaria-causing protozoan parasites of the genus *Plasmodium*.[13] Eventually, however, the realization was made that chemicals like DDT do not simply exterminate

[12] Hajer's work on acid rain shares many analytical features with Litfin's work on ozone: Maarten A. Hajer and University of Oxford. Faculty of Social Studies., "The Politics of Environmental Discourse : A Study of the Acid Rain Controversy in Great Britain and the Netherlands," Thesis D Phil --University of Oxford 1993, 1993.

[13] For more on DDT, see "The Stockholm Convention" in chapter four.

problematic insects, then evaporate into the ether. Because such chemicals are not broken down in the course of poisoning plants and animals that contain them, they accumulate in higher concentrations at each successive trophic level.[14] This was the cause of Rachel Carson's much-discussed silent spring, as birds that fed upon poisoned insects themselves suffered the consequences of chemical toxicity.[15] The Carson example is actually an especially revealing one, when considering the ways in which environmental issues arise in public consciousness and political debate; those that have a dramatic or photogenic dimension have better prospects for entering and remaining in the thoughts of busy politicians and members of the voting public.

DDT's secondary effects were initially taken to be fairly localized phenomena. The reasons for the presence of POPs in the Arctic, by contrast, remained mysterious until specific investigations of their behaviour in the atmosphere were conducted. Within Arctic food webs, POPs first affect lichens and mosses which then contaminate caribou herds; likewise, seals and walruses are poisoned by algae. At each level up the food chain concentrations are higher.[16] Because POPs concentrate in fatty tissues and those of marine mammals are an important food source for Arctic native peoples, these concentration effects have acute health consequences, especially for children and pregnant women.[17] Also, because of the importance of 'country foods' to the lifestyles of these groups, POP contamination

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[14] B. Commoner, P. Bartlett, H. Eisl and K. Couchot, "The Link between Anthropogenic Sources of Dioxin and the Human Food Chain: Source-to-Receptor Air Transport," Halogenated environmental organic pollutants and POPs; Dioxin 2000, ed. M. S. Denison (Monterey, CA: Emmenzeta, 2000), vol.
[15] Rachel Carson, Silent Spring (Cambridge, Mass.: Houghton Mifflin, 1962).
[16] Commoner, Barry et al. "The Deposition of Airborne Dioxin Emitted by North American Sources on Ecologically Vulnerable Receptors in Nunavut." In T. Fenge, David Leonard Downie and Inuit Circumpolar Conference., Northern Lights against Pops : Combatting Threats in the Arctic (Montreal ; Ithaca: Published for the Inuit Circumpolar Conference Canada by McGill-Queen's University Press, 2003) 87-108.
[17] Commoner, Bartlett, Eisl and Couchot, "The Link between Anthropogenic Sources of Dioxin and the Human Food Chain: Source-to-Receptor Air Transport," vol.

of marine and terrestrial food sources is a threat to culture, as well as health.[18] Given the certainty that these chemicals do not have their origin in the Arctic – where no industry or agriculture of a sufficient scale exists – the transmission of POPs raises serious normative issues. To what extent can those who suffer from the problem but are innocent in its causation make demands of others to change their behaviour? Also, the question arises of whether threats that critically threaten the way of life for a relatively small group of people justify policies that will diminish the welfare of far more people. In broader and more practical terms, the question also arises of how environmental moral claims can be meaningfully acted upon internationally.

Atmospheric distribution: toxins in the Arctic

Pollution from industrial and agricultural activity has been a well-known phenomenon at least since soot from British factories during the Industrial Revolution started to blacken forests, helping darker moths out-compete their lighter brethren. That said, pollution has generally been seen as a local, national, or regional phenomenon: something that can be managed on a limited geographic scale, sometimes requiring trans-boundary cooperation.[19] The science of POPs, however, has demonstrated that such pollution is a truly global phenomenon. Understanding how dioxins from garbage burned in Japan were poisoning the bodies of those living in the Arctic circle was one of the major consequences of the NCP and AMAP: the most substantial studies conducted on the atmospheric behaviour of POPs.

As described in the introduction, the NCP was initiated in response to very high levels of POPs discovered in the blood and breast milk of human inhabitants of Broughton Island, Nunavut in

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[18] Kuhnlein, Harriet, et al. "Canadian Arctic Indigenous Peoples, Traditional Food Systems, and POPs." and Watt-Cloutier, Shiela. "The Inuit Journey Towards a POPs-Free World." In Fenge, Downie and Inuit Circumpolar Conference., Northern Lights against Pops 22-40, 256-68.

[19] The Trail Smelter Arbirtration between the United States and Canada is an early example of trans-boundary pollution management.

1985.[20] Despite prior scientific investigation of POPs, the first indications that people in the region carried a heavy load of such contaminants in their bodies produced surprise and concern. Over the course of eight years, Indian and Northern Affairs Canada (INAC) coordinated a study involving Environment Canada, Health Canada, the Department of Fisheries and Oceans, as well as many scientists and volunteers – most of them part of Arctic native communities.

While the Stockholm process was ongoing, regional efforts to control POPs were also taking place. The CLRTAP was a regional mechanism maintained by the United Nations Economic Commission for Europe and meant to deal with many kinds of atmospheric pollution, (UNECE).[21] While their 1998 Aarhus Protocol was negotiated independently from the Stockholm Convention, many participants in the latter process identify the importance of the UNECE work to the development of the eventual global accord, partly by creating awareness among policy-makers that a global solution was necessary for the effective control of POPs. John Buccini, the chair of the Stockholm Negotiations, argued that the CLRTAP "indicat[ed] that the time was right to pursue a global agreement on POPs." [22] The CLRTAP and Stockholm Convention are discussed further in chapter four.

While scientific in character and approach, the Northern Contaminants Program was profoundly affected by political and bureaucratic structures. An illuminating contrast exists between Canada, where responsibility for POPs in the Arctic was given to Indian and Northern Affairs Canada (INAC) and the United States, where it was assigned to the Environmental Protection Agency (EPA). Henry Huntington and Michelle Sparck explain that American federal bureaucracies consistently downplayed or

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[20] See: Shearer, Russel and Siu-Ling Han. "Canadian Research and POPs: The Northern Contaminants Program." In Fenge, Downie and Inuit Circumpolar Conference., Northern Lights against Pops 41-59.
[21] For a more detailed history, see: Selin, Henrik. "The UNECE CLRTAP POPs Protocol." In Fenge, Downie and Inuit Circumpolar Conference., Northern Lights against Pops 111-32.
[22] Buccini, John Anthony. "The Long and Winding Road to Stockholm: The View from the Chair." In Fenge, Downie and Inuit Circumpolar Conference., Northern Lights against Pops 228.

ignored the danger of POPs, largely because the issue was such a small part of their mandate.[23] Since the role of the INAC centres on the groups of people most affected by the POPs issue, its bureaucratic control of the project helped to make the NCP successful. The active participation of Arctic native individuals and organizations was important both insofar as it helped with the technical work of the NCP and insofar as their inclusion conferred legitimacy upon the processes of investigation and deliberation.[24] While the external origin of the POP problem threatened to make Arctic native groups little more than passive victims, their initiative and inclusion helped to give them a role in shaping future policy within Canada, through the CLRTAP, and ultimately through the Stockholm Convention.

Climate change investigation

1896	Svante Arrhenius first calculates the possibility of anthropogenic climate change
1957	International Geophysical Year
1965	First scientific conference on the causes of climate change
1988	IPCC created

If it is difficult to identify the point at which the POPs issue was discovered, it is far more challenging to do so for climate change. Reaching the contemporary understanding of the issue has involved the work of thousands of scientists in dozens of disciplines, some of it reaching back over a century. Rather than a linear progression towards 'true' understanding, scientists have operated in a competitive arena, in which scientific issues have never been the sole focus. From the ways in which the Second World War and Cold War influenced the emergence of meteorology and climatology as modern scientific disciplines to the effect of the Reaganite and Thatcherite revolutions on American and British thinking about the environment[25], external forces have guided the kind of research that has

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[23] Huntington, Henry P and Michelle Sparck. "POPs in Alaska: Engaging the USA." In Fenge, Downie and Inuit Circumpolar Conference., Northern Lights against Pops 214-23.

[24] Jennifer Clapp and Peter Dauvergne, Paths to a Green World : The Political Economy of the Global Environment (Cambridge, Mass.: MIT Press, 2005) 79.

[25] See: Weart, The Discovery of Global Warming 142.

been funded, undertaken, and taken seriously. The evolution of climate science is intertwined with the evolution of geopolitics, technological capabilities, and related disciplines, as well as the evolution of the general understanding of the relationship between humans and the natural world. As such, all three elements of the climate change problem – facts, causal links, and values – were interacting and in flux during the course of identification and investigation. Especially important political factors were the connection between warfare and the development of environmental science, as well as changing cultural attitudes about nature and technology.

This section examines the key questions and causal linkages about which scientific consensus emerged late 19th century and up to the creation of the Intergovernmental Panel on Climate Change (IPCC) in 1988, while chapter three examines the mechanisms through which that took place, concentrating on the period between 1988 and the 2001 IPCC report.[26]

In 2004, Naomi Oreskes examined the content and conclusions of 928 scientific articles pertaining to climate change, representing 10% of the total published volume.[27] This study demonstrates the sheer quantity and variety of primary research that has been conducted on the issue. The history of this research is complex and revealing when it comes to the mechanisms of scientific investigation. The study demonstrated a remarkable consistency in the key conclusions reached by scientists about the nature and origin of climate change. Oreskes' conclusions – and those of the articles examined – demonstrate the importance of verification and trust. The following history is meant to demarcate the key developments in climatic science that have contributed to that scientific consensus.

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[26] For a much more comprehensive history, see Weart's The Discovery of Global Warming.[26]

[27] Naomi Oreskes, "Beyond the Ivory Tower: The Scientific Consensus on Climate Change.," Science 306.5702 (2004).

More than a century of science

Virtually every scientific discipline somehow pertains to the study of the Earth's climate. Geologists, biologists, and botanists have provided vital tools for examining past climatic situations and changes. Computer scientists have developed vital mathematical and statistical models. Oceanographers have examined important current and salinity issues, as well as feedbacks based on ice and thermal expansion. Physicists and chemists have investigated the essential interactions between solar radiation and atmospheric chemistry. Mathematicians have illuminated vital characteristics of complex, dynamic, and chaotic systems. Astronomers have provided insights into the importance of solar intensity, sunspots, and orbital changes; the study of the Martian and Venusian environments during the latter half of the twentieth century also provided insights into the nature of climate and climate changes. To begin with, these and many other disciplines pursued climate-related research independently from one another – separated by differing journals, methods, and internal cultures. While the progression from problem identification to consensus cannot be neatly split between investigative and discursive phases, this brief history will identify the origin of the key research upon which the present consensus on climate change rests.

Two major types of scientific development were essential for gaining an understanding of both natural and anthropogenic climate change. The first concerns scientific facts and methods, including tools for extracting and analyzing ice and sediment samples, the development of satellite technology, and the creation of much higher levels of computing power: all part of what Kuhn calls 'normal science.' Those computational tools are also closely connected to the second vital type of scientific development: the formulation of theories about how the various systems being studied function, from sunspots to the carbon cycle. Weeks of calculation done manually in the early twentieth century gave way to mechanical, tube-based, and ultimately transistor-based computers. Now, supercomputer clusters model the behaviour of dynamic forces in the world at a scale that would have been impossible even a decade ago. When observed facts and theoretical projections agree, the results are highly scientifically convincing. For instance, advances in the study of feedbacks in complex dynamic systems corroborated physical evidence of rapid climatic change in the past, making the possibility of future rapid change seem more credible. Likewise, when work in two vastly different disciplines proved complementary, it demonstrated that the results of both were reflective of real phenomena. Such verification mechanisms are vital to the credibility and effectiveness of science.

In 1859, John Tyndall first observed the ability of certain gases to trap energy from infrared light.[28] His earliest work was on methane – a greenhouse gas with an importance not fully recognized by scientists until the 1980s.[29] By 1896, Svante Arrhenius had speculated about the possibility of a connection between atmospheric concentrations of CO2 and ice ages, a subject that recent geological discoveries had made very prominent. Arrhenius anticipated the possibility of anthropogenic climate change through human emissions, but considered it only interesting theoretical possibility.[30] Twenty years earlier, James Croll first anticipated some of the reasons for which feedback effects are so critical for understanding complex dynamic systems like climate.[31] Those properties, as well as rapidly rising population, energy use, and fossil fuel dependency, helped to make Arrhenius' predictions manifest far earlier than he had ever considered likely. These early dabblings in climatic science received fairly little attention at the time and stand out in retrospect on the basis of how they suggest many things

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[28] John Tyndall, "On Radiation through the Earth's Atmosphere," Philosophical Magazine 4.25 (1863).
[29] A recent report from the United Nations Food and Agriculture Organization cites methane release from livestock production as a major contributor to climate change: representing approximately 18% of GHG emissions. UN Food and Agriculture Organization, "Livestock's Long Shadow –Environmental Issues and Options," (2006).
[30] Svante Arrhenius, "On the Influence of Carbonic Acid in the Air Upon the Temperature of the Ground," Philosophical Magazine and Journal of Science 5.41 (1896).
John Hardy, Climate Change: Causes, Effects, Solutions (Chichester: John Wiley & Sons Ltd., 2003) 13,55.
Weart, The Discovery of Global Warming 3.
[31] Weart, The Discovery of Global Warming 17-18.

now taken to be true. At the time, however, the disciplines of climatology and meteorology did not exist in any modern sense, and the dominant views about the basic dynamics of nature held that it was self-balancing by definition. Climate was simply average of the weather.

During the 20th century, both empirical findings and theoretical understandings about the climate expanded hugely. In 1938, Guy Callendar addressed the Royal Society in London, suggesting the possibility that the artificial production of CO2 could have a climatic effect.[32] His hypothesis built upon Joseph Fourier's work on the natural greenhouse effect; Fourier calculated that, without the heat absorbing properties of the atmosphere, the surface of the Earth would be below freezing everywhere.[33] This conformed with a general societal view that a balance of nature existed which kept conditions on Earth appropriate for human life. Such understandings, coupled with the seemingly slow growth of atmospheric CO2 levels, made the possibility of climate change an interesting topic for scientific study, but certainly not a matter for general attention. Over the second half of the century, a general feedback trend could be observed between the emergence of new information about the effects of human activity upon the world and a growing rejection of the self-regulating planet concept. Science was revealing the scope of human influence and vulnerability.

The 1950s through 1970s brought considerable advances in the understanding of Earth's climate. In 1955, Hans Suess demonstrated a notable increase in atmospheric CO2 concentrations during the previous hundred years. He later did important work with Roger Revelle – Al Gore's point of contact with climate science – on the absorption capacity of the oceans.[34] The period brought important new

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[32] G.S. Callendar, "The Artificial Production of Carbon Dioxide and Its Influence on Climate," Quarterly J. Royal Meteorological Society 64 (1938).
[33] Weart, The Discovery of Global Warming 2-3.
[34] Roger Revelle and Hans Suess, "Carbon Dioxide Exchange between Atmosphere and Ocean and the Question of the Increase of Atmospheric Co2 During the Past Decades," Tellus 9 (1957).

measurement techniques including the study of pollen using radiocarbon dating[35], the examination of foraminfera shells in oceanic sediment layers as a means of gauging past temperatures[36], and the examination of ice cores from glacial and polar regions for the same purpose.[37] These approaches provided some of the first evidence that big swings in climatic conditions could occur relatively rapidly – and did so convincingly, due to the diversity of methods and sources of materials being examined. This period also included the development of the first computer models of climate, essential tools given the impossibility of running planetary experiments. Theory development and model building both pointed to an enormous climatic importance for feedback effects, validating James Croll's suppositions from a century prior. One notable possibility that arose in the discourse is the idea that the thermohaline circulation, an ocean current that warms Europe, might be weakened or extinguished by global warming, reducing temperatures there substantially.[38] Increasingly, the climate did not appear to scientists like a stable order that could only be disturbed over thousands of years; small effects could be amplified through various feedback pathways, generating rapid and unpredictable changes.[39]

During the 1980s, climate change emerged as a relatively mainstream political issue. Whereas in 1981, only 38% of polled Americans recognized the term 'climate change,' the percentage grew to 79% in 1989.[40] A number of factors explain this trend: from the increased number of scientists doing

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[35] Hardy, Climate Change: Causes, Effects, Solutions 33-35.
[36] The practice of ice core sampling actually began in the International Geophysical Year of 1957-58. Samples collected in Greenland showed temperature data over more than 100,000 years, which was found consistent with other samples from Antarctica. Hardy, Climate Change: Causes, Effects, Solutions 29.
[37] Hardy, Climate Change: Causes, Effects, Solutions 31-33.
[38] Wallace Broecker, "Does the Ocean-Atmosphere System Have More Than One Stable Mode of Operation?," Nature 315 (1985).
[39] A dramatic example of this is the so-called 'butterfly effect,' used as an illustration of chaos theory. The idea that the flapping of a butterfly's wings in Brazil can cause a tornado in Texas highlights the power of feedback amplification, as well as chaotic interactions, within climatic systems.
See also: Weart, The Discovery of Global Warming 77.
[40] Weart, The Discovery of Global Warming 157.

interdisciplinary work on climate change to the new prominence accorded to atmospheric environmental issues in the wake of the ozone hole and the Montreal Protocol. In 1988, the Intergovernmental Panel on Climate Change (IPCC) was founded by the World Meteorological Association and the United Nations Environment Program. Both a scientific and a political organization, it would eventually produce the most widely researched and comprehensive pronouncements on climate change.

The influence of warfare and politics

Several connections between politics and science are especially relevant to environmental studies. One such example is warfare and international politics of conflict in the twentieth century. The very disciplines of meteorology and climatology emerged in something approaching their modern form during the Second World War – during which prevailing weather conditions, as well as the prospect of their alteration, were considered matters of national security. Were it not for the funding opportunities that arose from WWII and the Cold War, a great deal of the basic science behind our current understanding of climate change may have been done much later. The military development of technologies was also important, as was the increased scale and detail of data collection conducted by various armed forces. In a few notable cases, military activity also provided an unexpected and indirect aid to the study of climate.

The Second World War involved unprecedented meteorological study. Above all, this reflected the newfound importance of air power. Land and carrier-based bombers were a major part of the war effort in all theatres of operation and being able to understand and predict the conditions in which they would be operating had tactical and strategic importance. From Midway to Dresden to Tokyo, the status of wind and cloud patterns became a matter of intense concern. As such, the war years involved the first widespread, detailed, and systematic collection of global weather data. While such data was not generally standardized and aggregated at the time of collection, these records were later amalgamated, analyzed, and used to test climatic models.

Following the war, scientific competition with the Soviet Union generated funding for a great deal of basic research, as well as the kind with direct strategic applications (such as studies of radioactive fallout or the possibility of climate manipulation as a weapon). A fortuitous bit of funding produced one of the most famous graphs in the climate change literature: the one tracking CO2 concentrations at Mauna Loa in Hawaii.[41] Examining it closely, a gap can be seen in 1957, where David Keeling's funding for the project ran out. The Soviet launch of Sputnik I on 4 October 1957 led to a marked concern in the United States that American science and technology had fallen behind. One result of the subsequent surge in funding was the resumption of the CO2 recording program, which continues to the present day. While such fortuitous events were not strictly necessary for the evolution of climatic science, they certainly influenced the timing and sequencing with which important information became available to the scientific and political communities. Anticipation of political consequences of funding also shaped the formulation of research projects, as well as the presentation of results. Being able to impress the importance of one's research upon the policy-makers holding the purse strings can be as important as being able to prove its value to scientific colleagues.

Two more examples of military influences on climate research are worth mentioning. The first is the emergence of meteorological satellites, originally as secret military tools but eventually serving as a vital source of data to climatologists and meteorologists. The second was the usefulness of fallout from radioactive tests for the tracking of oceanic currents.[42] Unlike the atmosphere, where wind and temperature surveying had been happening since the Second World War, there were no systematic

[41] Reproduced in Weart (p.30), Gore (p.36-7).
[42] Weart, The Discovery of Global Warming 137.

records of oceanic data. By acting as tracers that could be measured with great accuracy, fallout from atomic testing allowed for oceanographic and ocean-atmosphere models to be improved. In a prior connection between atomic testing and climate science, Roger Revelle had actually been working on the Castle series of thermonuclear tests in the Marshall Islands when he did his first work on oceanic absorption of CO2.[43]

The influence of culture

The general conception of what 'climate' is changed considerably during the last century. Initially, it was seen as a stable average by definition. Weather varies, and climate is the sum of those variations. This view was challenged by the geological evidence of past ice ages: an anomaly that prompted much of the pioneering work on how the atmosphere, solar radiation, and other factors interact to direct climatic change. Over time, the recognition that human beings could and were having a profound effect upon the global environment helped to change the presuppositions with which scientists approached the investigation of climate change. Nuclear weapons, in particular, demonstrated such an awesome and pervasive human impact on the environment that they made it seem more plausible that the Earth's climate could be rapidly altered in general, as well as by human activity in particular.[44] If not entirely evident after the first military usages during the second world war, the extent of the danger posed by such weapons was revealed as the consequences of fallout and the combustion of cities became more thoroughly understood.[45]

General trends in politics also affect how information about the environment is interpreted. While this thesis cannot comprehensively examine the various national environmental movements of

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[43] Weart, The Discovery of Global Warming 29.

[44] John Robert McNeill, Something New under the Sun : An Environmental History of the Twentieth-Century World (London: Allen Lane The Penguin Press, 2000) 342.

[45] Carl Sagan, "Nuclear War and Climatic Catastrophe: Some Policy Implications," Foreign Affairs Winter (1983).

the 20th century, there do seem to be some important trends common to many western democratic states. For instance, during the 1960s and 1970s, taking environmental issues seriously became associated with the political left. This may be partly reflective of the greater willingness of those with that ideology to tolerate or encourage a broad governmental role. Conservatives, with their preference for limited government, have often sought to downplay the magnitude of environmental issues. This demonstrates some of the interconnections between values and judgment about fact. While a superficial reading would suggest that the conservative view is a kind of willful misrepresentation, driven by pre-forged interests, it is probably more accurate to say that information about environmental issues passes through complexes of existing heuristic filters, through which information is connected with existing understandings, and rankings of plausibility and urgency are assigned. These psychological processes will be more thoroughly considered in chapter three.

Themes and comparisons

Among the many themes that connect the case studies, three are especially useful for assessing the relationship between science and policy, in the area of problem investigation. The special properties of the polar regions make them critical locations where these activities occur, as highlighted by the ongoing 2007 International Polar Year. The fact that the Arctic is populated, unlike Antarctica, increases the normative importance of addressing problems that arise there. This is facilitated by the relatively high populations of northern Europe and North America, compared with the areas around Antarctica. Also vital to the process of problem investigation are the issues of trust and judgment (discussed further in subsequent chapters) and iterated approaches to policy development.

Special role of the Arctic

With the intention of detecting Soviet bombers and missiles coming across the pole, the United States and Canada constructed the 63 stations of the Distant Early Warning (DEW) line along the 69th parallel, 300km into the Arctic circle, between 1954 and 1957.[46] Their belief that threats could first be detected in the far north mirrors a contemporary scientific understanding. Because of their physical geography, as well as special features of their ecosystems, the polar regions are places where environmental changes – including problematic changes – tend to manifest themselves earliest and most forcefully. This is true of POPs and climate change, as well as the destruction of stratospheric ozone by free radical chlorine and bromine from CFC and halon breakdown. This special role grants opportunities to people living in the Arctic as well as policy-makers around the world, though the former must also live with the serious harms and threats that economic activity elsewhere has brought upon their region and way of life.

Environmental concerns affecting only the Arctic are unlikely to dominate political agendas. While the 150,000 people who live there will be intensely concerned by such threats, as will those who value the unique features of the polar regions, the kind of motivation for large-scale policy or economic change is unlikely to be present. By representing the far north as a kind of 'canary in the coal mine,' however, the inhabitants of the region can partially offset their marginalization. The burdens they bear, as the consequence of industry and agriculture elsewhere, may be indicative of what awaits the world if behaviours are not changed. Through the skillful use of scientific evidence and moral argumentation, the inhabitants of the far north need not be passive victims of environmental problems created elsewhere. This strategy has been applied with some success to the problems of POPs and climate change.

The careful monitoring of polar environments carries genuine benefits for policy-makers everywhere because of the extent to which it seems to be an indicator region, capable of demonstrating

[46] Incidentally, the PCBs in these decaying RADAR stations have contributed to the POP problem in the Arctic. In 1996, the Canadian and American governments initiated a $300 billion program to deal with the contamination.

facts and causal connections that might be obscured elsewhere.[47] Only by detecting POPs in such an unlikely place could their properties of atmospheric distribution and ecological dissimulation have been understood as quickly and effectively as they were.

Trust and judgment

Along with many other environmental policy processes, those leading to Stockholm and Kyoto show the importance of trust. One much-noted phenomenon is the preference of policy-makers for locally produced science. Litfin cites Margaret Thatcher's dramatic change of position regarding the regulation of CFCs as an example of such scientific nationalism.[48] Trust is also involved in the relationship between culture, politics, and science. Just as cultural understandings about the place of humanity in the natural world help condition expectations about which theories are plausible, cultural understandings about the credibility of specific theories and of science in general shape the willingness of policy-makers to pay heed to scientific conclusions. Ironically, the increased awareness of the human impact upon natural processes, which science has been instrumental in creating, also undermines some of the enlightenment-era faith that the application of scientific rationality to problems is always or generally beneficial. With the questioning of the rationality project, there is frequently a questioning of science as well. While it can be framed in terms of the precautionary principle – as Europe has done, in relation to genetically modified food – this may represent something more profound than skepticism about one particular technology. It may reflect suspicion or hostility to the general scientific approach to understanding and acting in the world: a position bolstered by the arguments of those who allege that the entire scientific enterprise is somehow dishonest or harmful.

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[47] For a discussion of some of the scientific research ongoing in 2007 International Polar Year, see: "Antarctic Science: To Coldly Go," The Economist 31 March 2007.
[48] Litfin, Ozone Discourses 127.

The importance of iteration in environmental policies

The iterative character of global environmental regimes – whether on POPs, climate change, or other areas – reveals the importance of ongoing re-evaluation in light of changing knowledge about the world, refined understandings of causal links, and changed normative understandings and priorities. Beginning with the Montreal Protocol on CFCs, international environmental agreements have frequently been established with provisions for periodic review.[49] This is an important reflection of the expansive nature of scientific knowledge and the dynamic nature of the human relationship with it. Both the Stockholm Convention and the UN Framework Convention on Climate Change (to which the Kyoto Protocol is such an expansion) include such mechanisms: a legal structure that ensures a continuous interaction between problem investigation, consensus formation, and policy (re)design.

In and of itself, the existence of iterative processes in environmental policy processes does not challenge the linear model of science-based policy-making: it simply suggests that the progression from science to policy choice to implementation happens multiple times. A more fundamental examination of the processes through which iteration takes place reveals that the relationship between science and politics is much more practically and theoretically complex than the linear model suggests. Iterated forms of environmental remedies have a number of features to recommend them, most of which will be taken up in chapter four. For the present, it is important to note how expert bodies delegated with specific tasks (such as to consider new substances to be restricted as POPs through the Stockholm Convention) have their investigatory task substantially modified as a result. While clearly not entirely divorced from politics, they are nonetheless operating in a clearly established political position. As

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[49] Litfin, Ozone Discourses 17.

such, their expertise is accompanied by a legitimacy derived from the negotiation and implementation of the framework in which they exist.

The mechanisms by which individuals and groups reach judgments about what is happening in the world, and what ought to be done about it, will be the principal subject of the third and fourth chapters.

Chapter 3: Consensus formation in science and politics

Because of the respective characteristics of science and policy-making, consensus is likely to emerge differently in each case. Two major properties of science give cause to expect consensus formation: the supposed relationship between scientific fact and ontological reality, and the social processes of science that serve to harmonize methods and understandings. In politics, by contrast, it seems plausible that disagreements over values and conflicts over interests will make consensus far more elusive. Thus, we might expect consensus to be the natural outcome of scientific processes, whereas political ones are always likely to retain elements of disagreement, rooted in competing interests and values. In the interaction of science and politics, each can serve both to reinforce and undermine consensus within the other. Scientists can be pushed into a united front by political issues, or driven apart by political meddling. Politicians can likewise be rallied by a seemingly strong scientific consensus[1], or they can exploit scientific arguments to entrench existing disparate positions.

When discussing consensus formation, the point must be raised again that problem investigation, consensus formation, and remedy design do not occur as a linear progression. The three are distinguished by the kinds of activity involved, rather than the period of time during which they occur. Furthermore, they are dynamically interlinked: the emergence of a technical fix to a problem will likely alter the ongoing investigatory efforts and the dialogue that has emerged around the issue. Advances in the design of internal combustion engines, for instance, allowed engine knock to be combated without the use of tetra-ethyl lead in gasoline.[2] Likewise, the advance of political consensus

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[1] For an example of how strong scientific consensus helped forge an environmental agreement between "sworn enemies," see: John Robert McNeill, Something New under the Sun : An Environmental History of the Twentieth-Century World (London: Allen Lane The Penguin Press, 2000) 146.
[2] McNeill, Something New under the Sun 62.

can drive various actors to generate remedies more urgently. The development of chemical substitutes to CFCs as the result of emerging political consensus is an excellent example.[3]

This chapter begins with a discussion of the importance of uncertainty in global environmental politics: focusing on how choices about how to deal with uncertainty are not simply technical. Those choices determine what risks will be run, and who will bear what share of the costs if they are realized. The chapter then briefly examines the formation of scientific and political consensus in the cases of POPs and climate change, focusing on how two the forms of consensus interact. In the case of climate change, the examination of scientific consensus covers the period between the establishment of the IPCC in 1988 and the release of the Third Assessment Report in 2001. The political examination extends somewhat further, with the caveat that it cannot run up to the present day. The political consideration therefore runs no further than initial responses to the Stern Review in October 2006. In the case of POPs, the period covered runs from the conclusion of Phase I of the NCP in 1997 to the 2001 Stockholm negotiations.

The first important matter to consider is the relationship between scientific and political consensus. The former is far less determinative of the latter than is commonly understood. Science rarely compels a specific policy response. Also, both are shaped by who participates in consensus formation and the social roles they adopt. The collection of voices that contribute to consensus formation is relevant for both normative and practical reasons. Social roles play a decisive role in how consensus formation transpires: specifically, the ways in which scientists and politicians understand the appropriate behaviour for each group involved in the process. The nature of advocacy, as practiced by

[3] Liftin argues that chemical firms denied the existence of substitutes until it became clear that regulation was imminent, at which point they rapidly became available: Karen Litfin, Ozone Discourses : Science and Politics in Global Environmental Cooperation, New Directions in World Politics (New York: Columbia University Press, 1994) 67, 94.

both expertise and legitimacy focused actors, is central to discursive strategies and the development of positions that can be embedded in policy.

The importance of uncertainty

> The more we learn about the world, and the deeper our learning, the more conscious, specific, and articulate will be our knowledge of what we do not know, our knowledge of our ignorance. For this, indeed, is the main source of our ignorance — the fact that our knowledge can be only finite, while our ignorance must necessarily be infinite.
>
> -Karl Popper[4]

In the arena of environmental politics, consensus is never built upon certainty. Models of the environment cannot replicate it entirely, and policy-makers cannot wait indefinitely for scientific investigations to conclude.[5] Four kinds of uncertainty are of particular importance to environmental politics: these are (a) uncertainty about what is happening in the world, (b) what causal mechanisms explain what is happening, (c) what the costs and benefits of particular activities are, (d) and who will bear those costs.[6] Costs and benefits cannot be sensibly expressed as single figures, but constitute ranges of possibility, often with a small chance of being much higher or lower than the mean prediction would suggest. Given the complexity of the climatic system, and the strength of feedback effects within it, the costs of climate change could end up being very far from the scenarios declared most probable by the IPCC. As Nicholas Stern explains: "the risks of outcomes much worse than expected are very real and they could be catastrophic." [7] The most worrisome scenarios involve unstoppable,

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[4] Karl Raimund Popper, Conjectures and Refutations : The Growth of Scientific Knowledge, Routledge Classics, 3rd ed. (London: Routledge, 2002).

[5] See: S. Boehmer-Christiansen, "`Global Climate Protection Policy: The Limits of Scientific Advice, Part 1', Global Environmental Change; Global Climate Protection Policy: The Limits of Scientific Advice, Part Ii', Global Environmental Change," International Library of Comparative Public Policy 11.2 (1999).

[6] The costs and benefits associated with possible alternative behaviours will be considered in the following chapter.

[7] N. H. Stern, The Economics of Climate Change : The Stern Review (Cambridge: Cambridge University Press, 2007) ix.

runaway climate change fed by strong positive feedback effects. Uncertainty of this magnitude has important normative and political implications.

The most political forms of uncertainty concern who bears costs and risks. Rather than trading between known interests prior to interaction – a standard game theory assumption[8] – agents bargaining about environmental politics are often seeking to shift unknown risks to other parties. The easiest such shift to accomplish is the transfer of risk to future generations, who are unable to participate directly in contemporary politics in any direct way.[9] But for the concern of present generations for those who are to follow, the opportunity exists to impose intolerable risks or actual burdens upon generations that will follow – a temptation exacerbated by the short-term nature of most political decision-making. This temptation is also worsened by the perverse incentives created by regulation structures operating across an uncertain timeframe, like the Kyoto Protocol in the post-2012 period. Also tempting for politicians and voters is the transfer of risk to other states. While mechanisms for managing such externalities have been developed in some cases, global environmental politics remains an area where such control is highly imperfect. This is especially true in situations where one state can 'free ride' in a way that causes a low level of harm to a great many others: even using a Coase-style analysis[10], the inefficiency of every state seeking remedy from Denmark or Liechtenstein over greenhouse gas emissions is obvious. This remains true even in situations where a clear and accepted international arbiter exists, to whom the injured party can appeal. Finally, there is the temptation to transfer risk within states from those who are powerful and politically influential to those who are not. The nature of

[8] For further examination of preference formation in the context of environmental economics, see: Vatn, Arild. "Efficient or Fair: Ethical Paradoxes in Environmental Policy." In Daniel W. Bromley and Jouni Paavola, Economics, Ethics, and Environmental Policy : Contested Choices (Oxford: Blackwell Publishers, 2002).

[9] Henry Shue makes much of the powerlessness of future generations, in setting out his argument about the immorality of inaction on climate change. See: Henry Shue, "Compounding Injustice and Globalizing Harm," trans. University of Reading, Global Justice and Climate Change (Reading: 2006), vol.

[10] Named after Ronald Coase, this economic theory holds that agents will be able to negotiate efficient solutions to externalities, provided the costs of bargaining are reasonable. The diffuse nature of the harm caused by many environmental problems is one of several potent criticisms of the theorem.

environmental problems and global economic activity requires that the 'black box' of the state be opened more often than in other areas of world politics. When the state of Florida provides hurricane insurance for multi-million dollar coastal homes in high-risk areas, such a transfer is taking place between more powerful and engaged taxpayers and less powerful and aware ones. Arguably, complex instruments like derivates in modern financial markets, allow firms with a superior understanding of risk to transfer it at a lower price than would be economically optimal, due to the naivety of those who purchase it.[11]

Economists use the term 'perverse incentive' to denote a consequence of an economic situation that runs counter to the intentions of those who established it: for instance, the risk that those with insurance will be more careless. In dealing with the political forms of uncertainty, and the kinds of perverse incentives that can arise, the combination of multilateral controls and iterative approaches can be very powerful. Universal participation in a system reduces the dangers of free riding. It also increases the probability that coalitions of states that have been harmed to a limited extent will be able to band together to seek redress from those states causing harm. As such, cooperative multilateral approaches to environmental management are often likely to be most efficient and effective. Iterative designs for international regimes dealing with environmental issues allow increased understanding about the problems in question to feed into the refinement of existing arrangements, reducing the length of time for which policies out of touch with the best current thinking will remain in operation.

Consider one concrete example of uncertainty: climate change damage curves. Assuming that climate change is an anthropogenic problem and that the damage caused increases as a function of greenhouse gas emissions, one can nonetheless imagine a number of possible shapes for the resulting

[11] See: Christopher L. Culp, Risk Transfer : Derivatives in Theory and Practice, Wiley Finance Series (Hoboken, N.J.: J. Wiley, 2004).
"Who's Carrying the Can?," The Economist 14 August 2003.

damage curve. The simplest possibility is a linear relationship: f(x) = A(x), where A is a constant defining the relationship between the damage caused by climate change in dollar terms and the aggregated concentration of greenhouse gases, in effect-weighted measurements of concentration.[12] More complex are non-linear curves. These could involve damage that increases at an increasing rate[13], damage that increases at a decreasing rate,[14] or a situation where the former switches to the latter at an inflection point.[15] In the case of rising GHG concentrations, the first implies ever-increasing damage without end. The second and third possibilities both level off at a plateau, though behave differently in the course of reaching it. Still more complex is the possibility of a curve with multiple stages, corresponding to thresholds at which major changes occur. If there is a threshold of greenhouse gas concentrations where, for instance, the ice shelves of West Antarctica melt and raise global sea levels by several metres, that portion of the curve may resemble a titration curve that levels off until another such threshold is met.[16] Some of the most worrisome possibilities in climate change involve the crossing of such sharp thresholds.

The policy implications of these scenarios differ considerably. Even more significantly, the inability to determine with certainty which possible curve best describes the potential damage from global warming makes it very difficult to address the problem in cost-benefit terms. Finally, the possibility of abrupt and potentially irreversible change makes the policy of waiting for new evidence to emerge and more research to be done highly risky.[17]

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[12] Not all greenhouse gasses contribute equally to warming. If the warming potential of carbon dioxide is 1, methane is 21, nitrous oxide is 310, hydrofluorocarbons are 140 to 11,700, perfluorocarbons are 6,500 to 9,200, and sulfur hexafluoride is 23,900. Source: Vattenfall, Curbing Climate Change: An Outline of a Framework Leading to a Low Carbon Society (Stockholm: Vattenfall, 2006), 47.

[13] Where the first and second derivatives of f(x) are both positive. This is the general curve shape anticipated by the Stern Review: Stern, The Economics of Climate Change : The Stern Review vii.

[14] Where the first derivative of f(x) is positive, but the second derivative is negative.

[15] Similar to a titration curve in chemistry, or the UN population projections for the next century.

[16] C.G. Rapley, "Absent Leadership and Shrinking Ice: How They Are Connected and What to Do," (2007), vol.

[17] Shue, "Compounding Injustice and Globalizing Harm," vol.

Consensus and POPs

1991	Arctic Monitoring and Assessment Program (AMAP) established
	Phase I of the Northern Contaminants Program (NCP) begins
1993	Preliminary AMAP report
1997	AMAP publishes *Arctic Pollution Issues: A State of the Arctic Environment Report*
	NCP publishes *Canadian Arctic Contaminants Assessment Report (CACAR)*
1998	AMAP publishes *AMAP Assessment Report: Arctic Pollution Issues*

The existing scientific and political consensus about POPs derives largely from two studies. The first is the Northern Contaminants Program: a two-phase investigation undertaken by the government of Canada between 1991 and 2003.[18] The second is the Arctic Monitoring and Assessment Program, which has been organized and operated by eight Arctic states since 1990. Each investigation provided essential information about the behaviour of POPs in the environment and their biological effects. These studies formed the basis for the political consensus that ultimately led to the regional and global responses to POPs, through the Aarhus Protocol to the CLRTAP and the Stockholm Convention.[19] The new consensus incorporated previous knowledge about the biochemical effects of POPs with new knowledge about atmospheric transport and bioaccumulation. All three are examined in detail in the 1997 AMAP Assessment Report, as well as the 1997 CACAR report of the NCP. Collectively, these three phenomena explain why POPs are accumulating in the Arctic, as well as the major reasons for which this accumulation is problematic.

Again, it is worthwhile to stress that the progression from problem investigation to consensus formation is not a clearcut one. Problem investigation involved the collection and *prima facie* evaluation of information, without a great deal of consideration of the broader context in which it exists. Consensus formation is a pooling of information and expertise which includes deliberation. The latter

[18] Phase I: 1991 – 1997. Phase II: 1998-2003.
[19] For detailed histories of the AMAP and NCP, see the Reiersen and Shearer chapters in: T. Fenge, David Leonard Downie and Inuit Circumpolar Conference., Northern Lights against Pops : Combatting Threats in the Arctic (Montreal ; Ithaca: Published for the Inuit Circumpolar Conference Canada by McGill-Queen's University Press, 2003).

activity requires a higher order of judgment and analysis, making broad participation important for the development of an authoritative stance. The simultaneous and similar conclusions of the NCP and AMAP demonstrated a high level of scientific credibility that contributed to the success of the Aarhus Protocol and Stockholm Convention negotiations.[20]

Consensus and climate change

1990	IPCC First Assessment Report
1992	IPCC Supplementary Report
1995	IPCC Second Assessment Report
2001	IPCC Third Assessment Report
2006	Stern Review
2007	IPCC Fourth Assessment Report

The mandate of the IPCC is to "assess on a comprehensive, objective, open and transparent basis the scientific, technical and socio-economic information relevant to understanding the scientific basis of risk of human-induced climate change, its potential impacts and options for adaptation and mitigation." [21] The IPCC has three working groups: one focusing on the scientific aspects of the climate system and climate change, a second working on assessing human vulnerability to climate change, and a third examining possibilities for mitigation. That mission, and the structure and composition of the organization, are all reflective of the inescapable links between the science being evaluated and the policy that will eventually be developed. As Keohane and Nye explain: "[t]he IPCC is an example of an information-legitimating institution whose major function is to give coherence and credibility to masses of scientific information about climate change." [22] Both coherence and credibility have a political component; coherence requires the integration of new information into existing conceptual frameworks which often include ideological components. Credibility is tightly connected to trust and judgment,

[20] See the Selin and Downie chapters in: Fenge, Downie and Inuit Circumpolar Conference., Northern Lights against Pops.
[21] Intergovernmental Panel on Climate Change, Principles Governing Ipcc Work (Vienna: 1998).
[22] R. O. Keohane and J. S. Nye, "Power and Interdependence in the Information Age," Foreign Affairs 77.5 (1998): 92.

largely predicated on heuristics used to evaluate information and the application of social roles.[23] The wide-reaching implications of climate change make it impossible for any comprehensive scientific assessment to be undertaken in ignorance of the political realities of the world: a situation perhaps most clearly demonstrated by the process of line-by-line revision of the IPCC summaries for policy-makers by representatives of member governments. The science may be able to speak authoritatively, but the representations made by the IPCC are filtered through a system where considerations of interest and remedy design are considered.

When discussing the emergence of consensus on climate change, there is the danger that one will simply end up chasing the news. The issue is one in which new political and scientific developments have been a weekly phenomenon for years, and where attention has been concentrating intensely of late. As such, the examination here has been time limited as set out in the introduction to this chapter: focusing on scientific consensus formation up to the third IPCC report in 2001 and political consensus formation up to the initial responses to the Stern Review.

The nature of climate

As discussed in chapter two, the process of consensus formation on climate change has involved a considerable re-imagining of the nature of climate itself. Many pre-twentieth century perspectives assumed that the human impact was either too small to have a substantial global effect or that the world climate system was fundamentally self-balancing. The increasingly widespread belief that human beings do have a big impact, and that they can push whatever balancing systems exist beyond the bounds of self-correction, has been important for the development of precautionary thinking in environmental policy-making. Such a framework of understanding is also vital for grappling with the issue of climate

[23] See: "Trust and judgment" in chapter two.

change, given how the most critical elements of the problem relate to deviations from equilibrium conditions and the possibility of multiple stable equilibria.

Changed perspectives on nature's imperviousness to human behaviour have been brought about through dramatic demonstrations of the scale and impact of aggregated human behaviours.[24] Both acute crises, such as the Love Canal or Chernobyl disasters, and more gradual changes, like the depletion of strataspheric ozone, have helped shift the conventional wisdom towards the view that humanity can and is substantially altering the content and functioning of the planet. The twentieth century has provided ample evidence of the ability of humanity to come up against biological limits, whether those concern the quantity of old growth forest remaining, fish stocks, or atmospheric issues. While empirical phenomenon certainly contributed to this changed understanding the role of discursive evolution must also be considered. For instance, the attitudes that people have demonstrated towards whales and wetlands have changed demonstrably in recent decades.

Equilibrium is virtually never a situation in which no change is occurring. The equilibrium between products and reactants in a chemical reaction – or the one reflected in a stable share price on a stock market – exists because the number of operations in one direction is balanced by those going the other way: for instance, the amount of carbon dioxide being absorbed by the ocean equals the amount being released by it. At the aggregate level, the situation is a stable one. With regards to the environment, equilibrium situations include forests where trees are being cut down at the same rate as others are reaching maturity. Some understanding of the establishment and maintenance of equilibrium is thus essential to the practice of sustainable development. Of course, the idea of 'development' implies ongoing change, rather than a steady state.[25] The degree to which that is possible in a finite

[24] McNeill, Something New under the Sun 358.

[25] See: Anil Markandya and Kirsten Halsnaes, Climate Change and Sustainable Development : Prospects for Developing Countries (London: Earthscan, 2002).

world with a growing human population remains highly contentious among those with differing views about the relationship between humanity and the environment, particularly between liberal environmentalists and bioenvironmentalists, to use the categorizations of Dauvergne and Clapp.[26]

The nature of equilibria remains an area in which fallacious reasoning abounds. While it is tautological to assert that stable situations will outlast unstable ones, it is not valid to extrapolate from that the idea that disrupted equilibria will always tend back towards their original state. While a marble at the bottom of a bowl will return to that position if temporarily dislodged, one balanced on the top of an overturned bowl will shift permanently to a new equilibrium position if it is pushed. The first situation is a stable equilibrium, while the second is not. There are also circumstances in which one type of system turns into the other: tip a vending machine over a bit and it will totter back to its original stance when released, tip it far enough and it will fall over. The idea that natural systems on a global scale can perform in both of these ways is a comparatively recent one, and one with profound implications for policy. Indeed, it is precisely the risk of catastrophic and irreversible change that has pushed many individuals towards advocating preventative measures.[27] When it becomes clear that hillsides denuded of trees don't necessarily trend towards reforestation, and depleted fisheries do not necessarily trend towards their original species mix, the costs of over-exploitation become greater, and the dangers of irreparable harm much more considerable.[28]

The present understanding of important climatic feedbacks includes those within and between the hydrosphere (liquid water on the surface of the earth), cryosphere (frozen water), atmosphere,

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[26] Jennifer Clapp and Peter Dauvergne, Paths to a Green World : The Political Economy of the Global Environment (Cambridge, Mass.: MIT Press, 2005).
[27] For instance, see: "The Heat Is On," The Economist 9 September 2006.
Henry Shue also attributes special moral importance to such possibilities. See: Shue, Henry. "A Legacy of Danger: The Kyoto Protocol and Future Generations." In Keith Horton and Haig Patapan, Globalisation and Equality, Routledge/Challenges of Globalisation ; 1 (London: Routledge, 2004).
[28] Thomas Lovejoy, "Climate Change: Prospects for Nature," (2007), vol.

biosphere (plant, animal, and microbial life), and lithosphere (geological features). Especially worrisome ones include the possibility of major ocean current disturbances (especially the themohaline circulation)[29], more frequent and severe natural disasters, agricultural problems arising from changed growing conditions, and large-scale displacements of population on account of rising sea levels. Along with agricultural considerations, warmer winters are also likely to encourage the spread of pests and disease.[30] Runaway climate scenarios are generally predicated on the risk of decreased albedo (the proportion of sunlight reflected) through ice loss and/or massive methane release from melted permafrost or subsea deposits.

The UNFCCC process

1992	Earth Summit (UNCED) in Rio de Janeiro
1995	COP-1 in Berlin
1996	COP-2 in Geneva
1997	COP-3 in Kyoto (Kyoto Protocol agreed)
1998	COP-4 in Buenos Aires
	COP-5 in Bonn
2000	COP-6 in The Hague
2001	COP-6 "bis" in Bonn
	COP-7 in Marrakech

The development of international political consensus on climate change can be most directly tracked through the UNFCCC process initiated at the 1992 Earth Summit. The framework convention called for annual Conferences of Parties (COPs), through which participating states could reach agreement on how to respond collectively to the challenged posed by climate change.[31] The first COP, in Berlin, led to a two year Analytical and Assessment Phase, meant to help with the development of a

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[29] John Hardy, Climate Change: Causes, Effects, Solutions (Chichester: John Wiley & Sons Ltd., 2003) 11, 35, 136, 38.
Wallace Broecker, "Does the Ocean-Atmosphere System Have More Than One Stable Mode of Operation?," Nature 315 (1985).
[30] "All Washed Up," The Economist 7 April 2007.
[31] For a longer summary of the negotiations at each COP, see: John R. Justus and Susan R. Fletcher, Global Climate Change (Washington: Congressional Research Service: Library of Congress, 2001).

"comprehensive menu of actions" for policy-makers.[32] It also began the process of negotiations on burden-sharing, introducing the concept of 'common but differentiated responsibilities' eventually incorporated into the Kyoto Protocol, as adopted at COP-3 in 1997. In that agreement, most industrialized countries (including the United States) agreed to binding reductions in GHG emissions.[33] COP-4 through 7 largely centred around disagreements about technical details of Kyoto implementation, as well as potential mechanisms for enforcement. Five COPs have taken place since 2001, but it is reasonable to say that the release of the Third Assessment Report of the IPCC in 2001 demonstrates the emergence of a general scientific consensus about climate change.[34] Generally, the UNFCCC process reflects political and ideological disagreements more than differing conceptions about the nature and importance of climate change. The negotiations demonstrate the extent to which the fundamental societal changes potentially required to stabilize GHG concentrations cannot be accomplished by purely technical means, even if the necessary science and technology seems to be available.

The Stern Review

The Stern Review begins by saying that the scientific consensus on climate change "is now overwhelming: climate change presents very serious global risks, and it demands an urgent global response." [35] The review was prepared in 2006, at the request of the British government, and tries to assess the economic consequences of both action and inaction in response to climate change. The degree to which this report is seen as authoritative, as well as the level of media attention devoted to

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[32] Justus and Fletcher, Global Climate Change.

[33] Partly due to hostility in the Senate (and Senate Resolution 98, which forbade the US from ratifying an emissions treaty that placed no restrictions on India and China), the Clinton Administration never submitted Kyoto for ratification.

[34] Spencer R. Weart, The Discovery of Global Warming, New Histories of Science, Technology, and Medicine (Cambridge, Mass.: Harvard University Press, 2003) 191.

[35] Stern, The Economics of Climate Change : The Stern Review i.

it, reveals something about the importance attached by policy-makers and the general public to predictions that have monetary figures attached. While the science of the Stern Report rests squarely on the prior conclusions of the IPCC, the framing of that information in a new way generated new thinking. It also did so in ways not limited to the United Kingdom. While it is far too soon to assess the historical impact of the review, the key conclusions (that the cost of addressing climate change is modest and that the costs of inaction are high and uncertain) may very well play a role in strengthening future international political consensus.

Deliberation, prioritization, and social roles

> Unlike asymmetrical interdependence in trade, where power goes to those who can afford to hold back or break trade ties, information power flows to those who can edit and credibly validate information to sort out what is both correct and important.
>
> -Robert Keohane and Joseph Nye[36]

Within both science and politics, there are two kinds of consensus worth contemplating: fact consensus and action consensus. Scientists, for instance, have an ongoing factual disagreement about whether global warming caused by anthropogenic emissions causes extreme weather events. The level of agreement on this is reflected in the wording of the executive summary to the fourth IPCC report (with the full body to be released shortly).[37] While scientists can generally be expected to agree that more study is a valid action in response to almost any determination of fact, consensus about what political action to take may never be universal. Likewise, once facts become weapons deployed in political arguments, the likelihood of entrenched disagreement increases.[38] Political stances can acutely affect the ability of both scientists and policy-makers to evaluate new information.

[36] Keohane and Nye, "Power and Interdependence in the Information Age," 89.

[37] See: Intergovernmental Panel on Climate Change. Working Group I, Climate Change 2007 : The Physical Science Basis : Summary for Policymakers (Paris: IPCC Secretariat, 2007).

[38] See: Kornelia Zukowska, "Investigating the Use of Science in Drafting the Ec Biomass Action Plan," MSc, University of Oxford, 2006, 21.

Understanding the nature and emergence of scientific and political consensus requires the consideration of human psychology; these processes depend upon the mechanisms through which individuals reach judgments about the nature of the world and choose how to act within it. Also important is the emergence of groups with shared cognitive characteristics, such as the epistemic communities described by Peter Haas[39] and members of paradigmatically defined scientific groups as elaborated by Thomas Kuhn. Patterns of individual evaluation and social grouping influence how scientific ideas form and enter into the realm of politics, as well as offer insight into the ongoing interplay between political and scientific modes of deciding. Two specific dimensions of consensus formation are especially important for this discussion: the issue of who participates in consensus formation, and the importance of social roles.

Who participates in consensus formation?

The means by which a particular conclusion is reached has considerable importance for determining how valid and accepted that conclusion will be. Participants who feel as though they have played a part in the process of discussion, had their opinions and concerns expressed, and materially contributed to the consensus formed are more likely to see it as authoritative and a justifiable basis for future action. When considering the global environmental politics of POPs and climate change, two groups are particularly important: the stakeholders most affected by each phenomenon and private sector actors contributing substantially to each issue. In some sense, these are both 'optional' participants in deliberations. The interests of stakeholders can be approximated by elected representatives, without direct consultation, and regulation can be imposed upon industry without consideration of any arguments they may advance. The reasons for which governments choose to engage

[39] For much more on the epistemic communities perspective, see: Lindsay Johnson, "Advocates, Experts or Collaborative Epistemic Communities? Defining the Scientific Role of Ngos in International Environmental Negotiations," University of British Columbia, 2006.

with such actors, in the formulation of policy, are threefold: they are uniquely positioned to provide high quality data to experts, they have their own expertise about the issues at hand, and their participation lends legitimacy to the process, both from their point of view and from those of other interested outsiders.

The Northern Contaminants Program (NCP) provides an excellent example of the value of stakeholder groups as data providers. The NCP relied heavily upon Arctic inhabitants as volunteers: both carrying out the physical tasks involved in the investigation and serving as subjects for it. Their participation is highlighted as an important reason for the success of the program by many of those who administrated it or interacted with it. Furthermore, the involvement of these groups bolstered the legitimacy of both the conclusions of the NCP and of the policy development processes that emerged from it. This role was played without a great deal of direct political influence. Rather, arctic native groups were able to influence policy development largely through the creation of a compelling discourse about the unfairness of their position and what ought to be done in response to the problem. It is notable, perhaps, that virtually all accounts of the Stockholm Convention negotiations mention specific symbolic acts that Arctic native groups performed, such as the presentation of a carved figure of a mother and child which sat beside the chair of the negotiations for their duration.

When it comes to evaluating the impacts of ongoing behaviours, as well as possible alternatives, parties other than scientists and politicians often have considerable expertise to offer. As such, their participation can broaden the debate and reduce the costs of investigation associated with it.[40] While the danger of self-interested groups attempting to act as spoilers during the process of investigation cannot be discounted, the difficulty of identifying the interests and agendas of special interest groups is generally surmountable. Policy-makers know enough to take the views about the

[40] C. Gough and S. Shackley, "The Respectable Politics of Climate Change: The Epistemic Communities and Ngos," International Affairs 77.2 (2001).

connection between coal power and climate change propounded by coal miners and owners of coal utilities with skepticism. Nonetheless, the participation of such actors can be essential for the development of policies that adequately take into account the viability of competing alternatives. The effective participation of such groups requires that policy-makers have the ability to uncover what motivates their strategic behaviour and to create incentives that will redirect that behaviour towards the outcomes the policy hopes to achieve.

Aside from their two contributions to the 'expertise' side of the equation, optional parties are capable of bolstering the legitimacy of a consensus. The breadth of political and scientific participation in the IPCC is very frequently highlighted as one of the key reasons for which its conclusions are credible. Such credibility makes it more plausible that states will be willing to bear the costs associated with acting on the conclusions of the body. Legitimacy can thus be seen as having both practical and normative value. For example, policy-makers hoping to create a national park would likely recognize that the support of local people is necessary if the park is to be respected. Such support is more likely to arise from a process of consultation that included them than from a decision simply handed down from on high. The normative value of legitimacy is equally intuitive; policy-makers whose authority results from representing the will of their constituents have a duty to consult with those people.

Discussing environmentalism and democracy, Terence Ball outlines both the practical and normative virtues of participation in democratic decision-making. On the practical side, he cites the fact that previously disenfranchised societal groups, including women and former slaves, would not be content to have their interests represented by previously enfranchised individuals with a newfound concern for them. Ball explains that "to extend moral recognition but not democratic-political representation does not offer adequate (or indeed any) protection of... interests." [41] The practical issue is both about knowledge (since people know their own interests better than even honest representatives would) and trust (because agents can never be entirely trusted to avoid using the power with which they are entrusted for their own benefit, rather than that of their principals). According to Ball, the normative importance of consultation can likewise be defended on the basis of two simple moral imperatives: the Golden Rule and the concept of *quod omnes similiter tangit ab omnibus comprobetur* – 'what touches all should be decided by all.' [42] Hypothetical thinking based on the Golden Rule can be a mechanism for addressing the problems of inter-generational justice in a democratic system since the kinds of behaviour we would have wanted from our ancestors are likely to be similar to the preferences future generations will have about our conduct. The latter principle is an assertion of democratic ideals over the competing notion that technocracy or some other form of non-democratic, expertise-based decision-making is more desirable. This assertion relates to a critical tension in the environmental movement: between an idealization of empowerment as a route to ecologically desirable outcomes and the recognition that empowered groups will not always behave as environmentalists may wish. The contested notion that broad participation does or does not foster effective policy is central to the macro-level debate about participation in environmental policy-making.[43]

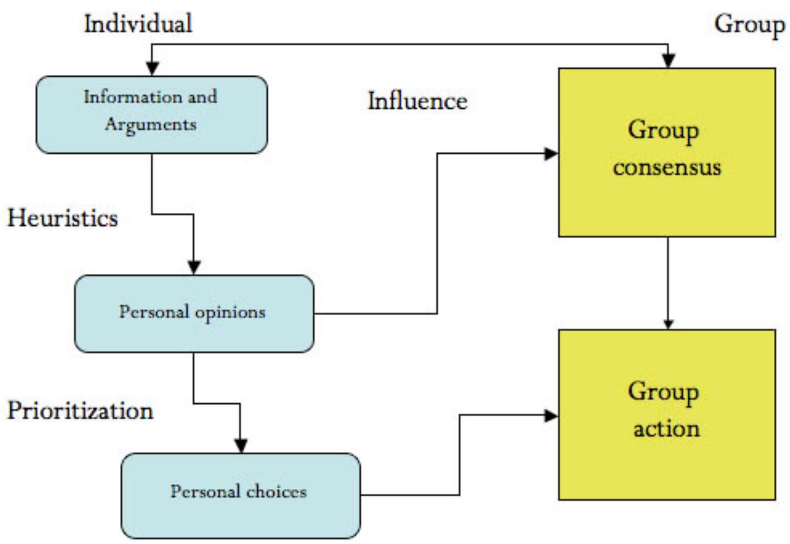
The importance of social roles

One traditional view of human beings is that they are logic machines: organisms with identifiable interests and capabilities, trying to achieve certain objectives. For Thomas Hobbes, these mechanical people primarily seek security; for contemporary economists, 'utility' is the ultimate

[41] Ball, Terence. "Democracy" in Andrew Dobson and Robyn Eckersley, Political Theory and the Ecological Challenge (Cambridge: Cambridge University Press, 2006) 139.
[42] Ball, Terence. "Democracy" in Dobson and Eckersley, Political Theory and the Ecological Challenge 136-7.
[43] Elizabeth Fisher, "Beyond the Science/Democracy Dichotomy: Law, Risk Regulation and Administrative Constitutionalism," (2006), vol.

commodity sought in life. This viewpoint is defective, with regards to the environment, for two major reasons: the theory of interest formation implied is faulty, as is the conception of the nature of goal seeking behaviour. Both can be effectively accessed through the consideration of social roles and the effect they have upon individual determinations of fact and appropriate action, as well as the ways in which those behaviours manifest in groups. Social roles are patterns of information evaluation and action prioritization deemed to be constituent of a discrete mental schema that is either impressed upon a person by particular surroundings or intentionally adopted. An inculcated social role is akin to that of a lawyer in the justice system; an adopted one is akin to that of a juror. The following flowchart reveals the key linkages:

Data to action flowchart



The factor most commonly excluded from mechanical conceptions of behaviour is the constant and widespread use of heuristics in decision-making. While there are certain restricted cases in which formal logic can bridge the gap from intention to action, the vast majority of decisions require the weighing of differing impulses and values in a way that cannot be expressed or solved through a syllogism or system of predicates. Heuristics are rules of decision-making that operate as part of the human logical apparatus but which do not, in and of themselves, have a necessary logical basis. These assist in information processing and prioritization in circumstances too complex to address comprehensively. Examples include conceptions of who or what kind of information is trustworthy (people are more willing to accept new information that seems to bolster their pre-existing views), intuitions about which problems to prioritize, and facts so conclusively believed that they can be used as a touchstone against which other logical arguments can be compared. Someone who has deeply accepted the idea that the total human population the earth can tolerate is a set figure will thus have difficulty accepting the argument that human ingenuity can increase that figure for a very long period or indefinitely. Crucially, the comparison being done is not a logical evaluation of two competing claims on the basis of merit; rather, it is the examination of the new claim in search of consequences that would clash unacceptably with a cherished existing view.

In addition to such general heuristics – which it is plausible to think arise partly in response to societal influences – there are specialized logical processes that attach themselves to particular social roles. Consider the case of a criminal trial. The roles assigned – prosecutor, defence attorney, juror, judge – affect the ways in which the individuals occupying them address the facts and arguments at hand. Judges and lawyers bring expertise to the legal process, while jurors largely exist to confer legitimacy. This specialization has been intentionally constructed into the court system, on the basis of the idea that a group of people playing such specialized roles are capable of being more effective in the enforcement of the law than a similarly sized group simply deliberating in their normal personal capacities. While the roles of scientists and politicians are not so temporarily or explicitly assigned, there are nonetheless features common to that dynamic and that of the courtroom. One could imagine the fact of DDTs toxicity being 'put on trial.' One phase, akin to the determination of guilt or innocence, would consist of evaluation of the claim by various means. While scientists might investigate on the basis of experiments and real-world observations, others may be convinced by a compelling narrative such as the one famously provided by Rachel Carson. Once some determination has been made, the issue of appropriate response arises and, along with it, a new set of considerations emerges on issues like the consequences of banning or sharply reducing DDT usage. The complexity of the scientific relationship with the environment in which they operate is partly reflective of their level of investment in that system: as such, they engage in higher level strategizing than would be the case if their sole activity was data evaluation.

Conclusions

Even more than the instant of problem identification, the moment of consensus formation is illusory. On a sufficiently important topic, there will always be some scientists and policy-makers who retain differing perspectives, both on the nature of what is happening in the world (this chapter) and what is to be done about it (chapter four). Of course, both systems can tolerate some level of deviation and disagreement; the critical point is thus where the balance of influence shifts from those favouring one broad interpretation to those favouring another. That can take the form of the emergence of a new group into power or through the emergence of a new and convincing discourse about an issue.

Also untenable is the idea that scientific and political consensus on environmental problems can be neatly separable. Politicians engage with science in a manner dependent upon their capability to understand it, ideological leanings, and personal agendas. Scientists actively manage their statements so as to retain credibility in the eyes of policy-makers and the public. While such behaviour can arguably be beneficial (because it provides an incentive not to present uncertain positions as factual), it can also cause problems both directly and indirectly. Direct problems arise from the possibility of poor decision-making based on information presented for tactical reasons. Indirect problems include the erosion of credibility that can occur when science is visibly politicized.

Chapter 4: Remedy design and implementation

> Technology is not an unsolvable problem, given time and incentives, neither is financing. The real challenge is policy. Will it really be possible for policy makers to get their act together in due time? To be very short, they have to, otherwise humanity will not be able to curb climate change.
>
> -Vattenfall (Swedish energy company)[1]

Problem investigation and deliberation are driven by the need to choose how to act. Naturally, the kind of alternative remedies known to exist will have a bearing upon both investigation and consensus formation, further entrenching the interconnected nature of the three activities. Possible remedies range from the simple upholding of the status quo to the outright prohibition of previously unregulated activities. In the processes of remedy design and implementation, scientists continue to play a privileged role. Their expertise permits the effective investigation of policy options – with projected impacts for each being generated. Their social roles and perceived analytical qualities also grant them the opportunity to influence areas where their scientific training is not necessarily relevant. The tension between scientists who wish to enlarge their influence through such routes and those who see the very nature of science as requiring them to only speak about matters of technical expertise is mirrored in the wider community. While scientists only rarely discuss such issues explicitly, good examples can be found in situations where scientists feel compelled to respond to politically charged situations. Examples include the Campaign for Nuclear Disarmament and the publication of Bjorn Lomborg's The Skeptical Environmentalist. In such cases, scientists explicitly and publicly debated the proper role for those of their profession when dealing with issues that are politically controversial.

This debate about the real and ideal forms of scientific engagement with regime design shares many characteristics with debates about the role of scientists within the activities already described.

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[1] Vattenfall, Curbing Climate Change: An Outline of a Framework Leading to a Low Carbon Society (Stockholm: Vattenfall, 2006), 38.

Once again, the key tension is between questions of expertise and expediency and those of legitimacy, as defined in the introduction. Scientific knowledge is necessary in order to craft effective remedies, which is to say those that deal with the problem in question, without generating even worse effects of their own.[2] When considering remedies, the issue of effectiveness and that of legitimacy are not effectively separable. Conceptions of fairness and institutional legitimacy play a major role in the effectiveness of remedies, largely because they help to establish ways in which various actors will behave towards one another and towards the regulatory regimes that are established. As during the process of consensus formation, the intensity of debate about remedy design increases along with the cost and importance of the problem being addressed. As such, the proper behaviour for scientists in relation to the problem of persistent organic pollutants is less actively disputed than their proper role with regards to climate change.

This chapter begins with an examination of the societal position of scientists as agents involved in remedy design. It then examines the activities of remedy design in the cases of POPs and climate change, including regional efforts to deal with POPs through the Convention on Long-Range Transboundary Air Pollution (CLRTAP), as well as global efforts through the Stockholm Convention. On climate change, both the Kyoto Process and the EU Emissions Trading Scheme are examined: the former as part of a general framework of response and the latter as a specific measure meant to achieve the overall ends of the climate change regime.[3] Following those is a thematic examination of the relationship between science and economics, in the circumstances of remedy design, and a discussion of the institutional embedding of scientists.

[2] Numerous examples exist where attempted remedies to environmental problems have generated consequences even more severe than the initial issue they were meant to resolve. For instance, plant and animal species introduced into certain areas to stabilize terrain or eliminate pests have often proved uncontrollable.

[3] An alternative example could have been the Clean Development Mechanism (CDM), in which the role of scientists and scientific knowledge is also prominent.

Scientists in society

> Take notice, this ["rash treatment of the truth"] is *not* due to primary research in the environmental field: this generally appears to be professionally competent and well balanced. It is due, however, to the communication of environmental knowledge, which taps deeply into our doomsday beliefs. Such propaganda is presented by many environmental organizations… and is readily picked up by the media.
>
> -Bjorn Lomborg[4]

> Unlike the search for knowledge, which is accepted as a legitimate practice, the search for allies must be disguised by other professional activities. Ultimately, this necessity is rooted in the larger belief that science is objective and value-free, while political life is ideological and value-driven.
>
> -Karen Litfin[5]

When environmental issues become the subjects of policy, a fundamental tension arises in the societal role of scientists. On the one hand, there is a mechanical ideal of the scientist as a collector and explainer of information: a role that does not encompass value judgments or advocacy behaviour. Kuhn appeals to this ideal in saying that "[o]ne of the strongest… rules of scientific life is the prohibition of appeals to heads of state or to the populace at large in matters scientific." [6] On the other hand, scientists have frequently seen themselves as having a duty to lobby for policies that conform to their conceptions and ideals about 'rational' behaviour. The latter role is also frequently invoked by members of the media and general public seeking to contrast the seeming impartiality and rationality of a 'scientific' approach with the self-interested choices and ambiguities inherent to politics. While the extent to which scientists can actually play an impartial role can be questioned, the concept nonetheless has considerable utility when examining how science is understood by different interested parties. For the purposes of this section, three major types of scientific activity will be considered: the formulation

[4] Bjorn Lomborg, The Skeptical Environmentalist : Measuring the Real State of the World (Cambridge: Cambridge University Press, 2001) 12. Emphasis in original.

[5] Karen Litfin, Ozone Discourses : Science and Politics in Global Environmental Cooperation, New Directions in World Politics (New York: Columbia University Press, 1994) 33.

[6] Thomas S. Kuhn, The Structure of Scientific Revolutions, 3rd ed. (Chicago ; London: University of Chicago Press, 1996) 168.

of predictions, the development of new technologies and techniques, and the consideration of 'big ideas' about the world.[7] These three kinds of involvement are applicable to two different types of remedy for environmental problems, which I shall term *intensity* and *substitution* remedies, respectively.

The first type of response to an environmental problem is changing the *intensity* with which an activity is being conducted. Factories emitting acid rain generating sulfur dioxide can be encouraged to reduce emissions, required to do so, or obligated to somehow isolate the sulfur dioxide produced from the external environment.[8] The two extreme edges of this type of policy option are continued unrestrained permission for anyone to engage in the activity under consideration and the complete prohibition thereof. Limitations through regulatory or economic means are of intermediate forcefulness. In many ways, intensity-based approaches are similar to different forms of liability under tort law.[9] This is because their application immediately raises entitlement and allocation issues. If the pollution being emitted is considered comparable to a nuisance being addressed in a tort suit (such as excessive noise or smell from one dwelling annoying the inhabitants of another), several legal remedies are possible. The court might grant an injunction, forbidding the party causing the nuisance from doing so. The court may uphold the right of the agent generating the nuisance to continue[10], potentially allowing the other party to negotiate some price at which they will voluntarily desist. It may assert the right of the party bringing the suit not to suffer the nuisance, potentially allowing the party that wishes to continue the activity that produces the nuisance to bargain with the injured party for the right persist. Finally, it may forbid the behaviour of the injuring party in a way that offers no scope for

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[7] An alternative seven-part categorization is in: Kornelia Zukowska, "Investigating the Use of Science in Drafting the Ec Biomass Action Plan," MSc, University of Oxford, 2006, 12.

[8] Naturally, the same is true of factories emitting CO2. Rather than using scrubbers to remove sulfur dioxide from flue gas, they might be required to sequester the CO2 they generate.

[9] See: Vatn, Arild. "Efficient or Fair: Ethical Paradoxes in Environmental Policy." In Daniel W. Bromley and Jouni Paavola, Economics, Ethics, and Environmental Policy : Contested Choices (Oxford: Blackwell Publishers, 2002).

[10] 'Right to farm' legislation in the United States performs a function of this sort.

bargaining. All of these options have the potential to generate an economically efficient outcome, though there are clearly normative differences between them.[11] Note that an outright prohibition is unlikely to be economically optimal, unless the interests of non-bargaining parties are taken into account.

The second major type of policy is to force the use of *substitute* means to the same end. Rather than ban automobile air conditioning, governments can mandate the use of non-ozone-depleting refrigerants. Likewise, governments can require that the pesticides used in farming or other forms of insect control not persist in the environment or bioaccumulate, or that a proportion of energy generated be based on renewables. In some ways, such requirements are similar to an outright ban. They are distinguished because alternate means to the same end are explicitly envisioned. Here, the uncertainties relate both to the impact of different possible approaches and to the state of development of alternatives in the near and long-term.

The availability and affordability of substitutes and alternative technologies is a crucial consideration in the development of environmental policy.[12] It is rarely politically possible to simply forbid or sharply restrict a substance or activity when there are no mechanisms to achieve the same end by different means. Just as restricting ozone-depleting CFCs would have been far more difficult without both near-term and long-term substitutes available, the roster of chemicals in the Stockholm Convention was dependent upon at least the perception that industry and agriculture could find alternatives. That said, the existence of alternatives is not exogenous to the policy process – particularly industry expectations about future regulation. The acceptance of industry that restriction of

[11] Schmid, A. Allan. "All Environmental Policy Instruments Require a Moral Choice as to Whose Interests Count." In Bromley and Paavola, Economics, Ethics, and Environmental Policy : Contested Choices.
[12] For a general discussion of trends in technological development and world politics, see: R. O. Keohane and J. S. Nye, "Power and Interdependence in the Information Age," Foreign Affairs 77.5 (1998): 87-94.

CFCs and POPs was inevitable prompted behavioural changes important to the success of the Montreal Protocol and Stockholm Convention.[13] A similar transition could occur with regard to climate change.

Scientists have a necessary minimum role in developing and applying both intensity and substitution-based remedies. When establishing intensity-based responses, scientists are called upon to make predictions about the outcomes that would arise from establishing regulations in differing ways. For example, marine or forestry scientists try to estimate the level at which a fish stock or forest can endure harvesting for an indefinite period.[14] These predictions describe both first and second order phenomena: the former being educated guesses about the results of a particular activity upon the world, the latter being about the quality of the first-level predictions, the ways in which they are most likely to fail, and the kinds of uncertainty that remain. The reports of the IPCC, NCP, and AMAP include both kinds of prediction. In the case of substitute-based approaches, scientists are called upon to play a similar evaluative role, as well as a developmental role in the generation of new technologies. Technological development is probably the least controversial role played by scientists, given how essential their expertise is to the process and the universal perception among policy-makers, scientists, and the general public that such development is within the purview of science. Beyond these necessary minimums, scientific involvement can easily extend to advising about what forms of decision-making are rational or prudent in a given situation, what kind of risks and uncertainties to devote the most resources towards abating, and what kind of ontological and normative arrangements human beings should establish with nature and with one another. Particularly when engaging with these higher level questions, the participation and appropriate role of scientists becomes contested. This is the product of the dilution of scientific expertise when dealing with such questions, as well as the lack of obvious legitimacy among scientists when speaking on behalf of those other than themselves.

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[13] Litfin, Ozone Discourses 118.

[14] Effectively, the point at which the rate of resource exploitation equals the rate of resource regeneration.

At the highest levels of prioritization, scientists are called upon to answer more fundamental questions about the nature of the human relationship with the world: such as the possibility of limits to growth. Those disparagingly termed 'neo-Malthusians' assert that there are absolute upper boundaries to the scale and intensity of human exploitation of natural resources, and that such limits are likely to be reached in the relatively near future. A more optimistic perspective contends that such limits ultimately do exist (how many humans can stand shoulder to shoulder on all the earth's land?), but that they will not be reached at any point in the foreseeable future. Finally, there is the exceptionally optimistic idea that whatever barriers appear in front of human beings will eventually be overcome. 'Bioenvironmentalism' as defined by Clapp and Dauvergne is largely predicted on the most pessimistic of those views, while liberal environmentalism ranges between the moderately and extremely optimistic options.[15] Clearly, the question of which view is correct is connected to the ontological reality of the world, as partially uncovered through the empirical examinations of scientists. Equally clearly, the scientific method does not allow as clear-cut an answer to be given to such questions as can be generated for specific matters like the tensile strength of a particular alloy or the number of asteroids in a region of space. Such a broad and important question cannot be answered through what Thomas Kuhn calls 'normal science;' rather, there is the need for a higher order of consideration which cannot achieve the same level of rigour or objectivity.[16] The scientific contribution to such 'big issue' questions depends crucially upon perceptions about the appropriate social role of scientists, in relation to such questions, as well as upon the kind of heuristic devices used by scientists when answering them.

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[15] Jennifer Clapp and Peter Dauvergne, Paths to a Green World : The Political Economy of the Global Environment (Cambridge, Mass.: MIT Press, 2005).
[16] "The Nature of Normal Science" In Kuhn, The Structure of Scientific Revolutions.

Another such 'big issue' question is how policy-makers should deal with uncertainty. To what extent is it worth mitigating a particular risk? Is it more prudent to protect against specifically envisioned dangers, or bolster more general response capabilities?[17] Are there categories of risk that are more 'rational' to worry about or take action against? When should precautionary action be taken, and when is it more sensible to 'wait and see?' At various times, scientists have provided answers to all of these questions, yet none fall clearly and unambiguously within the bounds of science. All of the issues raised about uncertainty in chapter two continue to apply, with the addition of uncertainty about political processes, ideological issues, and normative judgments.

The more the responsibilities of scientists telescope beyond the areas where their expertise makes them indispensable (as it is during primary research), the more contentious their influence and involvement becomes. Partly in response to this, scientists have often been hesitant to back specific policy measures, in favour of offering 'neutral' guidance to those more specifically empowered to make such judgments.[18]

Remedy design in response to POPs

1972	United States bans DDT except for essential health purposes
1985	Canada bans all uses of DDT
1997	Formal negotiations on POPs begin under the CLRTAP
1998	Aarhus Protocol on POPs is finalized by 33 countries and the European Community, under the framework of the CLRTAP
	Stockholm Convention negotiations begin
2000	Final draft of Stockholm Convention agreed
2001	Stockholm Convention opened for signature

The disparate origins of POPs and the distances across which they can travel render their effective regulation difficult, largely on account of the need for international coordination. As such,

[17] The ultimate example of the latter strategy being to focus simply on economic growth, in the belief that richer future generations will be best placed to deal with any problems that arise.
[18] Litfin, Ozone Discourses.
Roger. A. Jr. Pielke, "When Scientists Politicize Science: Making Sense of Controversy over the Skeptical Environmentalist," Environmental Science and Policy 7.5 (2004).

while regional efforts to address them helped determine the collection of chemicals that it is possible and ecologically sensible to regulate, they could not apply those judgments at the appropriate scale.

Early efforts to regulate POPs internationally were organized through the UN Economic Commission for Europe (UNECE) and the 1998 Aarhus Protocol to the CLRTAP.[19] This focuses on sixteen POPs deemed to pose the greatest risks to human health. As with the later Stockholm Convention, these include pesticides, industrial chemicals, and unwanted by-products. Some chemicals are banned outright,[20] others have a date scheduled for elimination,[21] while still others face severe restrictions. The protocol establishes standards for the disposal of POPs, as well as for the incineration of different kinds of waste. While the specifics of the Aarhus Protocol will not be listed here, the agreement demonstrates the ability of groups of states particularly concerned about the environment to move forward early on new issues. In doing so, they can help to direct how later and more extensive international regimes emerge.

In the end, the Stockholm process centred on the regulation of the so-called 'dirty dozen' POPs: a collection of pesticides, industrial chemicals, and unintentional by-products. The table in Appendix I lists the twelve substances and their levels of restriction. Article 3 of the Stockholm Convention prohibits usage of Annex A chemicals and restricts those in Annex B. Division by chemical type, as employed in the convention, facilitates the development of reduction plans by industrial and agricultural users and producers of POPs. An alternative way of classifying the substances involved is into two groups: chemicals intentionally manufactured in the state in which they will be used, and unwanted by-products. The first (which includes all the pesticides) can theoretically be replaced with

[19] For a more detailed history, see: Selin, Henrik. "Regional POPs Policy." In T. Fenge, David Leonard Downie and Inuit Circumpolar Conference., Northern Lights against Pops : Combatting Threats in the Arctic (Montreal ; Ithaca: Published for the Inuit Circumpolar Conference Canada by McGill-Queen's University Press, 2003).
[20] Aldrin, chlordane, chlordecone, dieldrin, endrin, hexabromobiphenyl, mirex and toxaphene
[21] DDT, heptachlor, hexaclorobenzene, PCBs

alternative and less problematic chemicals. The latter requires the alteration of the primary chemical processes that generate them, in order to achieve mitigation. A good example of this is the regulation of garbage incineration in Article 5 of the Stockholm Convention, intended to reduce dioxin and furan release. Article 6 concerns the disposal of existing stockpiles of restricted substances. Thus, both intensity and substitution approaches are part of the overall Stockholm strategy for POP reduction. The convention includes provisions on information exchange, education, and research but lacks any strong mechanisms to enforce compliance; as such, the adherence of states to the terms is dependent on their continuing willingness to do so.

The listing in the convention does not include all possible POPs, nor does ratification obligate states to completely abandon all the chemicals listed. Some, like the pesticide Heptachlor, may be used in specific applications for which adequate alternatives are unavailable. Perhaps most notable, from an ethical perspective, is the exemption allowing the continued use of DDT for malarial control. This arose from a substantial debate about the appropriateness of using POPs in areas where they do not have substitutes, and where their application can save lives. In utilitarian terms, their usage is clearly justified: only 150,000 people live in the entire Arctic region, whereas up to three million people a year die of malaria, most of them children in poor countries.[22] The conflict over DDT highlights ways in which consensus among technical experts can be diminished by differing prioritization. Even the existing DDT restrictions have garnered significant indignation in the medical community. These highlight the ways in which prioritization is necessary in arbitrating between competing claims. The decision highlights how conclusions reached on the basis of different kinds of expert knowledge (and different cultures of experts) can yield starkly different policy prescriptions.

[22] Jeffrey Sachs, The End of Poverty : Economic Possibilities for Our Time (London: Allen Lane, 2005) 196, 98-88, 231.

Ultimately, the Arctic native groups involved in the Stockholm negotiations expressed their support for the position of the World Health Organization: namely, that the value of DDT for malarial control in certain regions was greater than the health burden imposed upon others by its toxic properties. The acquiescence of the key affected group helped to ensure that the exemption was granted. While this decision can be justified on numerous grounds, the incentives generated by it bear consideration. Just as Karen Litfin argues that strong regulation prompted the development of substitutes in the case of CFCs, Jennifer Clapp argues that the existence of exemptions for DDT in international environmental instruments has led to a "lack of funds for research on alternative means of disease control." [23] Means of curtailing such perverse incentives are difficult to build into international agreements, though iteration can help. As with other exemptions in the Stockholm Convention (and the Aarhus Protocol), the development of new substitutes may change the balance of costs and benefits in the future; this further demonstrates the need for an iterative process and a permanent regime capable of re-examining both the technical characteristics of the situation and the continued validity of trade-offs such as this one.

Many scholars commenting on the development of the Stockholm Convention discuss the contentious relationship between the convention and the Global Environment Facility (GEF):[24] a body established in 1991 to provide funding for environmental and conservation projects, as proposed at UNCED in 1992.[25]. GEF financing is focused on encouraging the usage of substitutes to POPs in areas where it would not otherwise the affordable, much like the Clean Development Mechanism of the

[23] Clapp and Dauvergne, Paths to a Green World 131.
[24] Within Northern Lights Against POPs, see: Downie (143), Bankes (170-1), Buccini (240,244), and Watt-Cloutier (262). Note that Buccini chaired the negotiations and Watt-Cloutier was the elected head of the ICC at the time.
[25] Since 1991, the Global Environment Facility has provided $6.8 billion in grants and generated over $24 billion in cofinancing from other sources to support over 1,900 projects that produce global environmental benefits in more than 160 developing countries and countries with economies in transition. Along with the Stockholm Convention, the GEF is the funding body for The Convention on Biological Diversity, the UNFCCC, and The United Nations Convention to Combat Desertification.

Kyoto Protocol. As in the case of climate change, the matter of funding is largely centred around distributive justice. The question of who should pay to remedy environmental problems has been answered according to numerous moral imperatives: that those responsible for the problem should pay, that all those affected by the problem should contribute equally to the solution (either in absolute terms of relative to their wealth), or that those with the greatest ability to pay should do so.[26] There is also the broad question of whether environmental agreements should serve broader redistributive agendas.

The similarity between the Aarhus Protocol and the Stockholm Convention demonstrates the existence of a reasonably robust consensus about the risk associated with different chemicals, the costs involved in their elimination, and the appropriate steps to be taken. As such, the emergence of the Stockholm Convention is most valuable because of the additional scale of application; while an initiative focused in Europe certainly had the ability to help control global POP emissions, it was not capable of addressing the problem in a comprehensive manner.

Remedy design in response to climate change

1992	UNFCCC concluded
1997	Kyoto Protocol negotiated
2004	Russian ratification triggers Kyoto Protocol's entry into force
2012	Kyoto period ends

The 1992 Rio Conference[27] produced the first multinational agreement intended to address the problem of climate change. Given the lack of binding targets, the UN Framework Convention on Climate Change (UNFCCC) can be seen more as an expression of concern than as evidence of determination to confront a problem. Signed on 12 June 1992, the accord included the United States and 152 other nations, all of whom committed to the aim of "preventing dangerous anthropogenic

[26] S. M. Gardiner, "Ethics and Global Climate Change," Ethics 114 (2004): 578-83.
[27] Formally the United Nations Conference on Environment and Development (UNCED), also commonly known as the Earth Summit.

interference in the Earth's climate system." [28] Despite the lack of specific targets or enforcement mechanisms, the iterative process surrounding the UNFCCC has the potential to guide the eventual emergence of an effective international climate management regime, involving all major states, industries, and climate altering gasses.

The Kyoto Protocol was agreed at the third Conference of Parties of the UNFCCC, in 1997. The protocol was never intended to comprehensively address the issue of global climate change. Even if fully implemented, it would only reduce the GHG emissions of some states a certain percentage below their 1990 levels. On a massive issue like climate change, it was likely impossible to pass directly from a complete absence of international agreement to the existence of a regime capable of effectively regulating GHG emissions. Kyoto required developed countries (Annex I) to achieve their agreed levels of reduction either domestically or through 'flexible mechanisms' like the Clean Development Mechanism.[29] Developing states, including India and China, are not obliged to make reductions, raising concerns about both the effectiveness and equity of the agreement. The obligations established run only until 2012, creating a substantial level of doubt within industry about what will follow.

Perhaps the Kyoto Protocol can be best seen as the scale model for an international climate change regime. The enthusiasm of states that have ratified the agreement to meet their targets has not been entirely consistent. Canada is likely to miss its target entirely, while Japan and the European Union are likely to rely heavily upon the 'hot air' generated from industrial decline in the former Soviet Union.[30] In order to generate the kind of reductions called for by the Stern Report, the Kyoto Protocol

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[28] See: John R. Justus and Susan R. Fletcher, Global Climate Change (Washington: Congressional Research Service: Library of Congress, 2001), 9.

[29] Notably, two thirds of all carbon credits traded through the CDM have been based on emission reduction projects in China. Nonetheless, China continues to add the equivalent of California's electrical generating capacity each year, 90% of it coal fired. See: "Grim Tales," The Economist 31 March 2007.

[30] "The Heat Is On," The Economist 9 September 2006.

"Selling Hot Air," The Economist 9 September 2006.

would need to be expanded in both institutional strength and membership. Likewise, the most difficult questions about burden sharing and North-South relations would need more durable and far-reaching answers. Based on the scientific consensus and the level of risk aversion endorsed by Stern, both widening and deepening is necessary to address the scale of the problem. If this coordination proves possible, it may improve the chances of dealing with other ongoing common property failures of lesser magnitudes: from global deforestation to the destruction of fisheries. The institutionalist hope that cooperation fosters further cooperation can be bolstered by some evidence from the environmental area.[31] Given the mutual interdependencies and overwhelming importance of protecting natural systems upon which all life depends, the global environment is an ideal test case for these ambitions. This interdependence has been increasingly recognized in treaties and by international courts. At the same time, the dispersed nature of emissions and the incentives to which they are related requires a tying together of national and international policies with local practices and initiatives, a reality that further increases the complexity of the coordination problem at hand. An effective regime for the management of GHG emissions would, almost by definition, be a significant advancement in global governance.

The EU Emissions Trading Scheme (ETS) is the only mandatory carbon-trading scheme in existence, created in conjunction with the 1997 Kyoto Protocol.[32] The objective of the scheme is to accomplish reductions in greenhouse gas emissions in the most economically efficient way. In 2005, more than 260 million metric tons of CO2 equivalent were traded. An important feature of the ETS is the extension of emissions regulation until at least 2020, allowing firms to make more long-term investment decisions. While the ETS has provided some useful information about the design of market-based responses to the problem of global warming, it has also demonstrated ways in which such

[31] A much more extensive discussion of this philosophy can be found in: Clapp and Dauvergne, Paths to a Green World 227.

[32] See: Ch. 4 in Stephen Henry Schneider, Armin Rosencranz and John O. Niles, Climate Change Policy : A Survey (Washington, DC; London: Island Press, 2002).

approaches can be problematic.[33] The decision to give away permits, rather than auction them, essentially granted firms a license to pollute. Many have also argued that too many permits have been granted, reducing the impact of the ETS upon actual emissions. Like the Kyoto Protocol, the ETS might be best viewed as part of a path towards an effective management regime: serving both to demonstrate the feasibility of affordable and market-friendly solutions to climate change and helping to deepen the conviction among policy-makers and the public that something can and ought to be done.

The ETS also represents a fairly explicit institutional endorsement of the liberal environmentalist perspective. The liberal environmentalist approach is essentially defined by the combination of optimism about the resilience of the environment and human ingenuity and faith in the power of market mechanisms to deal with problems, once they have been properly priced into the system. Indeed, this faith extends beyond the claim that markets can arrange incentives to deal with such problems – it goes on to assert that this generates the required changes at the least possible cost, because markets will be able to shift reductions towards the parties that are able to make them most efficiently.[34]

The relationship between science and economics

The engineering perspective on the nature of science envisions it as quite explicitly connected with economics, in a pragmatic way. When deciding what kind of bridge to build or whether to cut down a certain forested area, technical concerns contend with economic ones in the mind of a decision-maker. At a far larger scale, however, the connections between science and economics are more complex and ambiguous. Consider for instance the SRES scenarios employed by the IPCC for making

[33] See: "Climate Control," The Economist 15 March 2007.

[34] For further discussion of liberal environmentalism, see: Clapp and Dauvergne, Paths to a Green World.
Steven F. Bernstein, The Compromise of Liberal Environmentalism (New York: Columbia University Press, 2001).

projections about future climatic changes.[35] These take into consideration possible courses of economic development and demographic transition, both within the developed and the developing world. The need to do so forces IPCC scientists to make predictions about the future course of policy, as well as more technical developments. In generating such scenarios, there is a tension between capturing a breadth of options while simultaneously presenting information concise enough to be acted upon. Lomborg, for instance, criticizes the collection of IPCC scenarios in the third assessment report as overly complex.[36]

The economics of environmental politics are often reflective of deep philosophical commitments. This is well captured in Jennifer Clapp and Peter Dauvergne's discussion of four differentiable worldviews about the political economy of the environment: liberal environmentalism with its optimism and faith in markets, the institutionalist vision of cooperation through binding international structures, the bioenvironmentalist vision of humanity massively violating the biological systems upon which we depend, and the social green focus on global justice issues.[37] These views are as loaded with scientific claims as they are with ideological ones – alternatively positing an unlimited human ability to innovate and find alternatives to depleted resources or envisioning strict limits to growth. A similar argument is ongoing between Bjorn Lomborg and his critics. Given how scientific arguments bolstering one or another position are likely to be taken up by those who already adhere to that worldview, at the same time as contradictory evidence is downplayed on the basis of existing heuristic modes of thinking, the scientific contribution to the debate can never be one of neutral fact

[35] Intergovernmental Panel on Climate Change. Working Group I, Climate Change 2007 : The Physical Science Basis : Summary for Policymakers (Paris: IPCC Secretariat, 2007) 10, 14.
Schneider, Rosencranz and Niles, Climate Change Policy : A Survey 71-3.
[36] Lomborg, The Skeptical Environmentalist : Measuring the Real State of the World 264.
[37] Clapp and Dauvergne, Paths to a Green World.

determination and dissemination. On these 'big idea' issues, the social and philosophical aspects of science are at their most prominent.

Scientists embedded in institutions

The kind of science that eventually generates policy is rarely undertaken by lone researchers. Indeed, it is philosophically debatable whether such people are engaging in science at all, given the social character of the scientific endeavour and the importance of discussion and oversight for the establishment of scientific theories and the verification of scientific facts. Such an individual certainly is not engaging in science of the form that occurs in universities, corporations, and laboratories around the world today. As such, the social role of scientists exists within structures that constrain and direct the kind of endeavours that are undertaken, the kind of information that is considered valid and valuable, and the currents through which influence flows. Bureaucratic politics, institutional culture, and cooperation and competition between organizations all affect how science contributes to global environmental politics.

Perhaps the best way of understanding the continuum between a scientist performing acute research through to a politician setting national policy is in terms of the scale of the prioritization required. Just as lab managers need to consider more competing claims to resources than researchers, departmental and organizational heads have yet-broader choices to make. Ultimately, the extent to which an individual is called upon to make choices between alternatives that are in many ways incommensurable[38] establishes the social role they adopt, and conditions the kinds of heuristics they apply when evaluating information. The choices made by those at a high level of prioritization also reflect the importance and credibility assigned to different claimants, both by the administrators themselves and by the broader bureaucratic cultures in which they are embedded.

[38] Protect old growth forests or make prescription drugs affordable for the elderly? Ensure the physical security of the state or conduct research into alternative forms of energy?

The level at which prioritization takes place is central to the Lomborg debate. His argument that it is more cost-effective to promote development than to mitigate climate change arises from a double limitation. First, he imagines a relatively low stock of resources to be devoted to both tasks, and then he sets up a prioritization problem that includes both.[39] To conclude from such an analysis that spending to reduce emissions is a poor use of resources is not a conclusion valid across all ways of framing the question. An alternative approach, emphasized by Nicholas Stern, is simply to compare the approximate costs of spending on mitigation with the risk-weighted probable harm that will be done by any level of climate change (the damage curves discussed in chapter three).[40] Here, the prioritization question has been phrased as a single-issue analysis with a focus on relative, rather than absolute, costs. Both perspectives can be justified using the same data about the character of climate change, demonstrating the importance of prioritization modes to deciding outcomes. The broader context of one policy-maker's choices is also relevant; often, choices made by actors insufficiently powerful to single-handedly direct outcomes will reflect prisoner's dilemma or Nash equilibrium dynamics. This can be applied both to individuals within state bureaucratic structures and to states with a low level of influence upon the formulation of international regulations.

Conclusions

Expertise, as it has traditionally been understood, is a myopic phenomenon. The expert watchmaker or logger understands the peculiarities of their profession, but may be ill-placed to understand or address the position of those activities within the broader swathe of human activities in a

[39] See: Chapter 24 "Global Warming" in Lomborg, The Skeptical Environmentalist : Measuring the Real State of the World.

[40] N. H. Stern, The Economics of Climate Change : The Stern Review (Cambridge: Cambridge University Press, 2007) xi-xiv.

yet-broader natural world.[41] While there have been attempts to apply the discipline that characterizes expertise to very broad choices, these are generally highly sensitive to the technical elements in their modeling. The Copenhagen Consensus, for example, sought to evaluate the 'best' use for a set quantity of money, on the basis of rigorous cost-benefit analysis. The conclusions reached, namely that focusing on disease and nutrition would be most effective,[42] are vulnerable to the criticism that the ranking could be profoundly altered by changing modeling parameters. As with scientific consensus, expert agreement may reflect the existence of a collectively convincing narrative, rather than the existence of strong impartial justification. Ultimately, expertise cannot adjudicate between such high level choices - it can simply serve as a guide to a policy process founded upon a notion of legitimacy.[43]

As discussed in the context of consensus formation, there is a range of possible ways in which scientists can participate in the organization and operation of institutions. These vary in the degree to which they are controversial: largely on the basis of the extent to which a scientist in one position or another needs to make big-picture decisions about allocations between very different possible actions. Also controversial is the involvement of scientists in the determination of high order philosophical perspectives and priorities on matters like equity or risk management; while scientists as individuals are clearly legitimate participants in such processes, it is less clear if and how their expertise affects the role they can legitimately play in such deliberations.

The process of remedy design combines all the complexities and subtleties of politics with all the challenges presented to science by a complex and dynamic world. As such, mechanical or atomistic conceptions of how the process operates are unlikely to yield either an accurate description or formulas

[41] This myopia may be most disturbing in resource extraction industries, where loggers or fishers understand the resources they are employing very well, yet remain oblivious to the rate at which they are being destroyed.

[42] Bjorn Lomborg, Global Crises, Global Solutions (Cambridge ; New York: Cambridge University Press, 2004).

[43] Randall, Alan. "Benefit-Cost Considerations Should be Decisive When There is Nothing More Important at Stake." In Bromley and Paavola, Economics, Ethics, and Environmental Policy : Contested Choices.

for effective action. Insufficient attention has been paid to the importance of social roles, as well as the ways in which heuristics and value judgments affect the treatment of uncertainty. The institutional positions of scientists and policy-makers are likewise important in a way that extends beyond simple bureaucratic politics or game theory, taking in some of the discursive and ideational elements so convincingly described by Litfin.

Chapter 5: Conclusions

Humanity no longer has the luxury of being a peripheral species within the natural world. While John Locke could still envision the Americas as an essentially unlimited space,[1] there is no frontier remaining where limits of one kind of another cannot be anticipated. This new level of influence has substantial importance for international relations. The magnitude of humanity's ecological impact in the twentieth century suggests that a new level of scientific understanding and engagement is required from policy-makers, due to the existence of important issues that can only be addressed with such knowledge. Particularly on the issue of climate change, it seems possible that the kind of action or inaction undertaken by the international community will have a significant impact on the unfolding of the twenty-first century and beyond. The cases of POPs and climate change demonstrate the necessity of effective engagement with expert communities of scientists, taking into account issues like social roles and bureaucratic structures. Both cases also demonstrate how the behaviour of scientists frequently strays beyond the firm boundaries of areas where their expertise is clearly essential and appropriate, with ambiguous political consequences.

Effective engagement with environmental issues requires a more nuanced understanding of the scientific process and its operation in relation to politics. As an aspirational construct, the linear model of science-based policy-making highlights some important factors for appropriately combining expertise and legitimacy in policy-making. In particular, it highlights the problems that can arise when empirical and normative judgments become intertwined, as well as how ideological prejudices can influence how new information is evaluated and interpreted. The biggest fault lies not with the ideals embodied in this model, but rather with the belief that a clear delineation can be made between fact and value, between

[1] The only mechanism through which the 'Lockean Proviso' can be defended, since only the existence of essentially unlimited total resources allows anyone to make use of them while still leaving "as much and as good for others." Otherwise, since the last unit is out of bounds, the second to last unit must be as well, and so forth *ad infinitum*.

science and politics as they are idealized. The processes initiated by discoveries about POPs and climate change have largely reflected the interconnection of the two disciplines: particularly in terms of how consensus formation took place and how remedies were designed. The final way in which examples like climate change and POPs undermine the linear model of policy-making is insofar as they are very unlikely to ever be 'solved' once and for all. Their treatment will always reflect a balance between competing interests, some of which will always push for continuing emissions of POPs and greenhouse gases. This goes back to the initial definition of environmental problems in chapter two as the intersection between ontological phenomena, causal understandings, and preferences. Even if scientific progress generates more refined conceptions about the first two components, continued flux within the third will ensure that the equilibrium that emerges is a shifting one.

The separations between the three areas of activity examined in this thesis have broken down in a number of places, due to the enmeshed character of the processes involved. The three central chapters do not outline stages in a linear process, but rather types of activity that may occur in any sequence or in overlapping fashion. The processes of problem identification (especially in terms of preferential and normative judgments), problem investigation, and consensus formation are dynamically interlinked, each conditioning how progress in the others occurs.[2] Additionally, perceptions about the prospects and structures of possible remedy condition how problems are interpreted, and what forms of research are given priority. While analytical separation can yield insights into the different elements of these processes, the depth of their interlinkages must be stressed.

Comparison of case studies

Comparing the case of POPs with that of climate change, a number of general features of environmental problems and human responses to them can be identified. As described in the

[2] Thomas S. Kuhn, The Structure of Scientific Revolutions, 3rd ed. (Chicago ; London: University of Chicago Press, 1996) 138.

introduction, many features of the two cases are similar. For instance, both involve an unanticipated atmospheric problem that has arisen from large-scale modern industry and agriculture. As demonstrated by the vastly different levels of controversy attached to the Stockholm Convention and Kyoto Protocol, very important differences exist as well. Most important among those are inequality, the importance of scale, and the depth of uncertainty involved.

The POPs case and climate change case each reveal forms of inequality that exist within the international political system. Most prominent among these is the divide between 'developed' states and those that are 'developing.' This influenced the debate about financing the Stockholm Convention through the Global Environment Facility, as well as the concept of 'common but differentiated responsibilities' as embedded in the Kyoto process. The climate change case, in particular, demonstrates how different conceptions of the fair distribution of burdens can be a barrier to agreement and action. Consider the log-jam created by the differing perspectives on the problem of climate change in India, China, and the United States. The two former states refuse to accept binding emissions reductions, citing how the problem of global warming arose from the economic development of others, as well as how large fractions of their population continue to live in extreme poverty only likely to be alleviated through emission-generating economic growth. The United States, by contrast, refuses to adopt restrictions on the basis that they would create a competitive disadvantage against states that do not choose to do so. Such disagreements are largely political in nature, though they are influenced by the conclusions of scientists. Particularly important are scientific predictions about the costs of possible alternative policies, as well as those associated with inaction. The level of global interest in the Stern Review demonstrates how translating existing scientific consensus into monetary terms can attract the attention of both policy-makers and the public at large. As such, the framing of scientific conclusions has the capability to influence the processes of inter-state agreement about how to respond to environmental problems.

Inequality can also manifest itself in terms of differential access to the policy-making process. A clear example of this can be found in the distinctly different initial responses to the POPs issue in the United States and Canada.[3] The choice within Canada to assign responsibility for the issue to the department of Indian and Northern Affairs (INAC) led to a markedly different outcome from the American decision to grant organizational responsibility to the Environmental Protection Agency (EPA). The contrast illustrates the extent to which a certain level of entrepreneurship is important when dealing with international environmental issues, just as it is with other social concerns.[4] The issue of access also relates to the matter of who participates in consensus formation, as discussed in chapter three. Given the apparent preference of policy-makers to treat science developed by their own nationals as more credible, the broad participation in scientific investigations such as the AMAP and the IPCC can serve political purposes as well as scientific ones. Inequality in access to processes is also connected to varying levels of state capability: highlighting the importance of capacity-building and coalition formation as mechanisms for the empowerment of states that may otherwise be marginalized.

Climate change involves both a much higher overall level of uncertainty than POPs and a different collection of ways in which that uncertainty is manifest. The key questions concern the costs that would be associated with different forms of action and the distribution of those costs among different states and private sector actors. Whereas the POPs problem poses no known risk of catastrophic harm, climate change could potentially lead to changes in weather and agricultural

[3] See Huntington, Henry. "POPs in Alaska: Engaging the USA." In T. Fenge, David Leonard Downie and Inuit Circumpolar Conference., Northern Lights against Pops : Combatting Threats in the Arctic (Montreal ; Ithaca: Published for the Inuit Circumpolar Conference Canada by McGill-Queen's University Press, 2003).

[4] For example, the campaign to ban anti-personnel landmines through the 1997 Convention on the Prohibition of the Use, Stockpiling, Production and Transfer of Anti-Personnel Mines and on their Destruction (Ottawa Treaty).

capability that would have far-reaching effects upon all states and the general functioning of the international system. In addition to the existence of such catastrophic possibilities, the climate change case also involves a far greater number of feedbacks, as enumerated in chapter three. The complexity of these interactions complicates the process of scientific examination and reduces the extent to which authoritative predictions can ever be generated. These complications add to the difficulty of crafting a linear narrative about the development of climate science, as well as the migration of those conclusions into the realm of policy. Thomas Kuhn identifies a tendency to craft an artificially sequential and unambiguous account, when writing scientific history. This arises largely through the promotion of theories that were initially contentious but proved correct, while suppressing those that were later invalidated. The time compression between discovery of facts about the state of the world, causal understandings about the connections between chemical production and environmental consequences, and moral and political consensus about how behaviours should be altered makes it easier to craft a linear-seeming narrative about the POPs case.

In many ways, the POP issue and climate change are microcosm and macrocosm. Both centre on the inadvertent effects of human activity on atmospheric chemistry, with significant consequences for human, plant, and animal life. Both involve phenomena neither predicted nor understood until comparatively recently, and both involve some measure of scientific uncertainty. The differences lie primarily in scale: the potential costs and consequences of climate change seem to dwarf those of POPs by orders of magnitude. The number and extent of scientific studies and political deliberations in the latter case are likewise much greater. If the overall trend in human economic activity continues towards ever-greater interference in the operation of natural processes, it seems reasonable to think that future problems will manifest themselves at a greater scale than many of those in the past. Anecdotal evidence about the ongoing economic development in India and China, particularly, seems consistent with this view.[5] As such, the development of international relations theory that takes into account environmental issues, as well as the special properties of the science-policy relationship, seems likely to have utility for future scholars and policy-makers.

Major themes

In all three substantive chapters, there are a small collection of issues that arise continuously when contemplating the relationship between science and policy. The first is the importance of uncertainty: particularly the ways in which it is evaluated and acted upon. The second is the importance of social roles for understanding the generation of environmental policy, as well as for understanding the broader contexts in which that activity takes place. Third is the importance of process, both practically and normatively, in determining the workability and acceptability of policy outcomes. The idea that policies can be value-neutral or developed in an entirely neutral way is fallacious, and the explicit recognition of the moral determinations embedded in policy can help to unravel some of the complex interconnections that this thesis has described.

Uncertainty

As discussed at length at the beginning of chapter three, many forms of uncertainty are relevant to global environmental politics. The balance of influence and credibility between scientific and political actors is partially established through the mechanisms by which uncertainty is diminished, hedged against, and acted upon. In formulating policy, one needs to consider forms of uncertainty that are essentially scientific but which have political consequences. Further to that, it is necessary to consider uncertainty about factors that may not be very scientifically relevant (such as the economic competitiveness of American steel producers compared to their Chinese counterparts) but which have a

[5] "Grim Tales," The Economist 31 March 2007.

large influence upon the political acceptability and chances of success associated with a particular policy option.

Scientifically, environmental politics involves uncertainty about the ontological reality of the world both in terms of (a) the facts about objects and structures within that world and (b) the dynamic causal links between them. At the most macroscopic level, uncertainty about causal links leads to the special issues involved in dealing with complex dynamic systems, such as the biosphere or global climatic system. Developing mechanisms for modeling the present state and possible future trajectories of such equilibria is extremely challenging, particularly given the classical scientific approach of atomizing the subjects of study and developing an understanding of them from the bottom up. In addition to such uncertainties about the world, there are relevant social, moral, and political uncertainties. For example, there is the issue of how the costs of a policy or an outcome will be distributed within a population, as well as lack of certainty about the interests and preferences of present or future morally considerable beings.

Political uncertainty is largely a matter of individual decision-making and the incentives and patterns of thought that influence it. This partially manifests itself as bureaucratic politics within individual states and sub-state authorities. Scientific organizations and those with extensive scientific capabilities, such as the Environmental Protection Agency and the National Oceanic and Atmospheric Administration in the United States, engage in competition for resources and influence. This also occurs in inter-state negotiations and interactions between states and important private sector actors.

From the perspective of private actors, uncertainty about the future direction of policy is particularly relevant. As demonstrated in the case of ozone depletion, firms that anticipate regulation can be prompted to rapidly develop new technologies and business practices. Conversely, firms that are able to convincingly argue that such innovation is impossible or impractical may be able to lobby effectively to weaken emerging regulatory regimes. This dynamic can encourage strategic behaviour both on the part of industry and regulators. In the case of representations about the technical feasibility of different approaches, the practice of unbiased scientific assessment is important for uncovering which claims are strategic and which are more solidly founded on objectively verifiable phenomena. Likewise, the interaction between scientists and economists, as discussed in chapter four, helps with the evaluation of claims about what is or is not economically viable, as well as which groups are likely to benefit economically from different alternative forms of regulation. Given the long timescales involved in the installation of energy-generating equipment, long-term predictions of this kind are particularly important for the development of national and international policy on climate change.

A thought experiment helps to identify some of the ways in which uncertainty can never be entirely overcome. While the IPCC has generated some highly educated guesses, the ultimate scale of the climate change problem remains unknown. On account of the singular nature of the earth, it is also somewhat unknowable. Even with improvements to science, the full character of alternative historical progressions remains outside the possible boundaries of knowledge. As such, in a century or so humanity will find itself in one of the following situations:

1. Knowing that climate change was a severe problem, about which we have done too little
2. Believing that climate change was a potentially severe problem, about which we seem to have done enough
3. Believing that climate change was a fairly modest problem, to which we probably responded overly aggressively
4. Observing that, having done very little about climate change, we have nonetheless suffered no serious consequences.

Without assigning probabilities to these outcomes, we can nonetheless rank them by desirability. A plausible sequence would be 4 (gamble and win), 2 (caution rewarded), and then 1 and 3 (each a variety of gamble and lose). Naturally, given the probable variation in experiences with climate change in different states, differing conclusions may well be reached by different groups. Furthermore, in most possible outcomes, it will be impossible to know how greater or lesser investment would have affected outcomes. The example illustrates the three key categories of uncertainty described in this thesis: the kind relating to empirically observable features of the world, the kind relating to the behaviour of influential agents, and the kind which can never be overcome, given the limitations of investigation and the impossibility of assessing all possible consequences in all possible worlds.

Social roles

Social roles have likewise been a critical area of examination within this thesis: most importantly in terms of the ideal and real roles of scientists. Conceptions of what constitutes appropriate behaviour on the part of scientists shapes how such experts choose to behave, how they are perceived by policy-makers and the general public, and what sort of contribution they are able to make to the processes of policy development. In the study of global environmental politics, many other social roles could be usefully examined – including those of economists and the media. It can be expected that such professions face similar collections of expectations, as well as employ their own heuristic modes of evaluation and prioritization. The special features of science are largely those identified by Thomas Kuhn: the behaviours and thinking patterns inculcated by professional training and the mechanisms by which scientists scrutinize one another's work, thus helping to establish the shifting bounds of what constitutes good scientific practice.[6]

Social roles evolve in two ways: from the structures and circumstances in which actors find themselves (akin to judges and lawyers within the justice system) or through intentional imposition as part of a broader structure of decision-making (akin to the role of jurors). In turn, such roles largely establish whether the policy effectiveness of a particular actor is rooted in expertise or legitimacy, as defined in the introduction. The content of social roles largely consists of the kind of heuristic devices

[6] Kuhn, The Structure of Scientific Revolutions.

employed by individuals to evaluate new information, the mental processes of prioritization used to determine which new information is acted upon, and the personal and professional expectations that exist about what kind of action can be legitimately taken by an individual in a certain position. It is largely differences in these three categories that distinguish scientists from policy-makers, as well as advocates from experts. These categories do not, however, exist in an unwavering and objective format. Their ongoing contestation – particularly in terms of what constitutes appropriate behaviour for scientists – is an important source of change in the science-policy relationship, as well as the broader influence of science upon the evolution of world politics.

Process

Political theory has long highlighted the importance of process in determining the effectiveness and legitimacy of outcomes. On the matter of the environment, by contrast, there is all-too-often the belief that there is a single 'correct' policy in response to a particular problem and that all that needs to occur is the empowerment of those already suitably enlightened to implement it. In their most severe form, such attitudes are profoundly anti-democratic: founded upon the belief that the normal polity simply lacks the cognitive resources or self-control required to support appropriate policies.[7] Even more radical is the idea that automatic market processes can deal with any environmental problem, as long as all of the necessary information is internalized.[8] In such a determinedly free-market view, the only form of representation that is significant is the ability of actors to act through markets. Whether accepted or rejected, this position highlights the importance of the participation and influence of different actors. A critical dimension of process is the matter of who participates in decision-making

[7] An interesting discussion about the relationship between democracy and environmentalism can be found in: Ball, Terence. "Democracy." In Andrew Dobson and Robyn Eckersley, Political Theory and the Ecological Challenge (Cambridge: Cambridge University Press, 2006).

[8] An extreme form of this can be found in the Coase Theorem, though the more general concept can be found throughout the liberal environmentalist literature.

(as discussed in chapter three): especially the ways in which participation correlates with policy-effectiveness and the perception of legitimacy. Process also concerns how questions about burden sharing and distributive justice are decided: for example, in the case of the exemption in the Stockholm Convention for the use of DDT in malaria prevention, or that of the differential responsibilities established for developed and developing countries in the Kyoto Protocol. The last major area in which process is important is in the use of iterated approaches to address uncertainty. This allows action to be taken at a time when all relevant information has not yet been collected or analyzed, while maintaining the option of later revision. This adaptive character is important because of how new information about the world is always coming to light. It is also important because of how political and normative judgments are in constant flux.

A specific example of the importance of process can be found within the scientific community itself. Given the contentious nature of the engagement between science and politics, as well as growing recognition that scientific 'truth' is socially constructed, there is a distinct need for norms of professional conduct within the sciences, characterized by behaviours such as open criticism and willingness to re-evaluate claims when new data comes to light.[9] The credibility of individual scientists, scientific organizations, and the scientific community as a whole is dependent upon the maintenance of these patterns of interaction, as well as the perception among policy-makers and members of the general public that the most important scientific mechanisms and avenues of criticism are intact and functioning. An understanding of this dynamic motivates strategic behaviour on the part of both scientists and political actors. Scientists often recognize the extent to which seeming divisions within their community can be exploited by political actors with set agendas; the choice to either highlight the existence of such conflicts or seek to downplay them as a means of retaining influence is

[9] R. O. Keohane and J. S. Nye, "Power and Interdependence in the Information Age," Foreign Affairs 77.5 (1998): 92.

one of the most important ways in which scientists seek to maintain a balance between professionalism and an ability to influence political processes.

Implications

So far, the human record of dealing with the environment is not encouraging. Where moderation has dominated, it has generally been the result of physical barriers to human exploitation, rather than any kind of enlightened restraint. As a consequence, the world's old growth forests have fallen to axe and chainsaw[10], the fish stocks in all oceans have been scooped up by freezer-trawlers and seiners to the point of severe depletion[11], and an astonishing number of species have been driven to extinction, generally through habitat destruction.[12] Compounding humanity's lack of restraint in general are the specific characteristics of problems like POPs and climate change: their diffuse nature, the long timescales across which damage occurs, the uncertainty attached to them, and the economic importance of the activities that generate them. As such, overcoming problems of this nature is an essential and pressing challenge for humanity. Doing so requires the effective participation of both expertise and legitimacy-based actors.

Effective policy-making requires the consideration of all the major themes raised in this examination: from the relationship between scientists and policy-makers to questions of international distributive justice and the development of effective and equitable environmental regimes. Environmental politics is a field in which science has a vital role to play, though that role remains imperfectly understood and insufficiently scrutinized. For instance, the twentieth century gives ample reason to question both the truthfulness and the desirability of the engineering model of science, which

[10] See: John Vaillant, The Golden Spruce (Toronto: Random House, 2005).
[11] See: Charles Clover, The End of the Line : How Overfishing Is Changing the World and What We Eat (London: Ebury, 2004).
[12] See: John Robert McNeill, Something New under the Sun : An Environmental History of the Twentieth-Century World (London: Allen Lane The Penguin Press, 2000).

can achieve spectacular amounts of change, though often in the direction of undesirable ends. Largely, this is a consequence of how the scientific method can allow highly effective optimization of a narrow task, but rarely forces the consideration of the broader consequences of that action.

In the end, the science-policy relationship is connected to both major projects ongoing in the study of international relations. Explaining the relationship allows for the more effective categorization of how the international political system operates: both in terms of the behaviour of the units that comprise it and in terms of the systems in which those units are embedded. In particular, the study of science can provide insights into how interest formation takes place, the importance of ideas to the development of world politics, and the importance of discourse to determining outcomes. In all of these areas, a refined understanding of science can help to develop testable predictions about how particular circumstances will influence outcomes: for instance, how certain kinds of incentives presented to different states will affect their engagement with and commitment to international regimes. The study of science also empowers those who are seeking to alter the conduct of world politics. Those whose primary concern is to influence the human understanding of nature and the relationship between the two can gain from the examination of how 'big ideas' about the world emerge, are debated, and change. Those seeking to achieve greater international equity can likewise consider the impact of environmental factors upon human lives in different circumstances, as well as how burden sharing and redistributive arrangements have been and might be created within the environmental field.

Ultimately, the science-politics relationship connects directly to the most essential human activities: the comprehension of the world in which we exist and the evolution of mechanisms to live together within it. From this perspective, the present global situation is rife with both possibilities and dangers. Humanity has an unprecedented ability to interrogate the world, uncovering new information about its characteristics and interactions. That knowledge can be likewise be applied on a greater scale than has ever been possible before – as ever more people, and capital, and technology can be applied to any task being undertaken. Combined with the ignorance that endures and the tendency to make short-sighted decisions, that capability magnifies the risk that is inherent to the current relationship between science, politics, and the interactions between humanity and the outside world. If the potential that exists is to be realized, and the pitfalls which should be feared are to be avoided, humanity must continue to grapple with the nature and role of science.

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Treaties

Aarhus Protocol on Persistent Organic Pollutants (POPs) to the Convention on Long-Range Transboundary Air Pollution (CLRTAP)

Adopted: 24 June 1998

Parties: Armenia, Austria, Belarus, Belgium, Bulgaria, Canada, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Holy See, Hungary, Iceland, Ireland, Italy, Latvia, Liechtenstein, Lithuania, Luxembourg, Malta, Monaco, Montenegro, Netherlands, Norway, Poland, Portugal, Republic of Moldova, Romania, Russian Federation, San Marino, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, The Former Yugoslav Republic of Macedonia, Turkey, Ukraine, United Kingdon, United States, European Community

As of 21 March 2007

Source: http://www.unece.org/env/lrtap/status/98pop_st.htm

Full text available at: http://www.unece.org/env/lrtap/full%20text/1998.POPs.e.pdf

Convention on Long-Range Transboundary Air Pollution (CLRTAP)

Opened for signature: 13 November 1979

Entered into force: 16 March 1983

Parties: Albania, Armenia, Austria, Azerbaijan, Belarus, Belgium, Bosnia and Herzegovina, Bulgaria, Canada, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Georgia, Germany, Greece, Holy See, Hungary, Iceland, Ireland, Italy, Kazakstan, Kyrgyzstan, Latvia, Liechtenstein, Lithuania, Luxembourg, Malta, Monaco, Montenegro, Netherlands, Norway, Poland, Portugal, Republic of Moldova, Romania, Russian Federation, San Marino, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, The Former Yugloslav Republic of Macedonia, Turkey, Ukraine, United Kingdom, United States, European Community.

As of 21 March 2007

Source: http://www.unece.org/env/lrtap/status/lrtap_st.htm

Full text available at: http://www.opcw.org/html/db/cwc/more/long_range_air1979.html

Kyoto Protocol to the United Nations Framework Convention on Climate Change

Adopted: 11 December 1997

Opened for signature: 16 March 1998 to 15 March 1999

Entered into force: 16 February 2005 (55 parties and at least 55% of 1990 CO2 emissions equivalent by UNFCCC Annex I parties)

Parties:
Annex B: Australia, Bulgaria, Canada, Croatia, Czech Republic, Estonia, EU-15, Hungary, Iceland, Japan, Latvia, Liechtenstein, Lithuania, Monaco, New Zealand, Norway, Poland, Romania, Russian Federation, Slovakia, Slovenia, Switzerland, Ukraine, United States

As of 10 April 2007

Source: http://unfccc.int/kyoto_protocol/background/items/3145.php

As of 14 February 2007, 169 countries and one regional economic integration organization (the EEC) have deposited instruments of ratifications, accessions, approvals or acceptances.

List of statuses:

http://unfccc.int/files/kyoto_protocol/background/status_of_ratification/application/pdf/kp_rat_131206.pdf

Full text available at: http://unfccc.int/resource/docs/convkp/kpeng.html

Stockholm Convention on Persistent Organic Pollutants

Entered into force: 17 May 2004 (50th ratification)

Participants: Albania, Algeria, Angola, Antigua and Barbuda, Argentina, Armenia, Australia, Austria, Azerbaijan, Bahamas, Bahrain, Bangladesh, Barbados, Belarus, Belgium, Belize, Benin, Bolivia, Bosnia and Herzegovina, Botswana, Brazil, Brunei Darussalam, Bulgaria, Burkina Faso, Burundi, Cambodia, Cameroon, Canada, Cape Verde, Central African Republic, Chad, Chile, China, Columbia, Comoros, Congo, Cook Islands, Costa Rica, Cote d'Ivoire, Croatia, Cuba, Cyprus, Czech Republic, Democratic People's Republic of Korea, Democratic Republic of the Congo, Denmark, Djibouti, Dominica, Dominican Republic, Ecuador, Egypt, El Salvador, Eritrea, Ethiopia, European Community, Fiji, Finland, France, Gabon, Gambia, Georgia, Germany, Ghana, Greece, Guatemala, Guinea, Guinea-Bissau, Haiti Honduras, Hungary, Iceland, India, Indonesia, Iran (Islamic Republic of), Ireland, Israel, Italy, Jamaica, Japan, Jordan, Kazakhstan, Kenya, Kiribati, Kuwait, Kyrgyzstan, Lao People's Democratic Republic, Latvia, Lebanon, Lesotho, Liberia, Libyan Arab Jamahiriya, Lithuania, Luxembourg, Madagascar, Malawi, Malaysia, Maldives, Mali, Malta, Marshall Islands, Mauritania, Mauritius, Mexico, Micronesia (Federated States of), Moldova, Monaco, Mongolia, Montenegro, Morocco, Mozambique, Myanmar, Namibia, Nauru, Nepal, Netherlands, New Zealand, Nicaragua, Niger, Nigeria, Niue, Norway, Oman, Pakistan, Palau, Panama, Papua New Guinea, Paraguay, Peru, Philippines, Poland, Portugal, Qatar, Republic of Korea, Romania, Russian Federation, Rwanda, Saint Kitts and Nevis, Santa Lucia, Saint Vincent and the Grenadines, Samoa, Sao Tome and Principe, Saudi Arabia, Senegal, Serbia, Seychelles, Sierra Leone, Singapore, Slovakia, Slovenia, Solomon Islands, South Africa, Spain, Sri Lanka, Sudan, Suriname, Swaziland, Sweden, Switzerland, Syrian Arab Republic, Tajikistan, Thailand, The Former Yugoslav Republic of Macedonia, Togo, Tonga, Trinidad and Tobago, Tunisia, Turkey, Tuvalu, Uganda, Ukraine, United Arab Emirates, United Kingdom, United Republic of Tanzania, United States, Uruguay, Vanuatu, Venezuela (Bolivarian Republic of), Vietnam, Yemen, Zambia, Zimbabwe

As of 14 April 2007

Source: http://www.pops.int/documents/signature/signstatus.htm

Full text available at: http://www.pops.int/documents/convtext/convtext_en.pdf

United Nations Framework Convention on Climate Change (UNFCCC)

Opened for signature: 12 June 1992
Entered into force: 24 March 1994 (50th ratification)

Parties:
Annex I: Australia, Austria, Belarus, Belgium, Bulgaria, Canada, Croatia, Czech Republic, Denmark, Estonia, European Community, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Latvia, Liechtenstein, Lithuania, Luxembourg, Monaco, Netherlands, Norway, Poland, Portugal, Romania, Russian Federation, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey, Ukraine, United Kingdom, United States of America

As of 14 April 2007
Source: http://unfccc.int/parties_and_observers/parties/annex_i/items/2774.php

Annex II: Australia, Austria, Belgium, Canada, Denmark, European Union, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Japan, Luxembourg, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, United Kingdom, United States of America

As of 14 April 2007
Source:
http://unfccc.int/essential_background/convention/background/items/1348.php

Non-Annex I Parties to the Convention: Afghanistan, Albania, Algeria, Angola, Antigua and Barbuda, Argentina, Armenia, Azerbaijan, Bahamas, Bahrain, Bangladesh, Barbados, Belize, Benin, Bhutan, Bolivia, Bosnia and Herzegovina, Botswana, Brazil, Burkina Faso, Burundi, Cambodia, Cameroon, Cape Verde, Central African Republic, Chad, Chile, China, Columbia, Comoros, Congo, Cook Islands, Costa Rica, Cuba, Cyprus, Cote d'Ivoire, Democratic People's Republic of Korea, Democratic Republic of the Congo, Djibouti, Dominica, Dominican Republic, Ecuador, Egypt, El Salvador, Equatorial Guinea, Eritrea, Ethiopia, Fiji, The Former Yugoslav Republic of Macedonia, Gabon, Gambia, Georgia, Ghana, Grenada, Guatemala, Guinea, Guinea-Bissau, Guyana, Haiti, Honduras, India, Indonesia, Iran (Islamic Republic of), Israel, Jamaica, Jordan, Kazakhstan, Kenya, Kiribati, Kuwait, Kyrgyzstan, Lao People's Democratic Republic, Lebanon, Lesotho, Liberia, Libyan Arab Jamahiriya, Madagascar, Malawi, Malaysia, Maldives, Mali, Malta, Marshall Islands, Mauritania, Mauritius, Mexico, Micronesia (Federated States of), Mongolia, Morocco, Mozambique, Myanmar, Namibia, Nauru, Nepal, Nicaragua, Niger, Nigeria, Niue, Oman, Pakistan, Palau, Panama, Papua New Guinea, Paraguay, Peru, Philippines, Qatar, Republic of Korea, Republic of Moldova, Rwanda, Saint Kitts and Nevis, Saint Lucia, Saint Vincent and the Grenadines, Samoa, San Marino, Sao Tome and Principe, Saudi Arabia, Senegal, Serbia, Seychelles, Sierra Leone, Singapore, Solomon Islands, South Africa, Sri Lanka, Sudan, Suriname, Swaziland, Syrian Arab Republic, Tajikistan, Thailand, Timor-Leste, Togo, Tonga, Trinidad and Tobago, Tunisia, Turkmenistan, Tuvalu, Uganda, United Arab Emirates, United Republic of Tanzania, Uruguay, Uzbekistan, Vanuatu, Venuezuela (Bolivarian Republic of), Vietnam, Yemen, Zambia, Zimbabwe

As of 14 April 2007

Source:
http://unfccc.int/parties_and_observers/parties/non_annex_i/items/2833.php

Full text available at: http://unfccc.int/resource/docs/convkp/conveng.pdf

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Appendix I: POPs listed in the Stockholm Convention

Three types of POPs are regulated through the Stockholm Convention:

Chemical type	Stockholm-regulated substances
Pesticides	Aldrin (*), *Chlordane* (*), Dieldrin (*) *DDT* (*), Endrin, Heptachlor (*) *Hexachlorobenzene* (*), *Mirex* (*), Toxaphene
Industrial Chemicals	PCBs (*)
Chemical by-products	Dioxins (**), Furans (**)

* Restricted usage permitted under the Stockholm Convention
** Stockholm signatories obligated to implement reduction strategies
Limited production of italicized items permitted
Source: Stockholm Convention. Annex A "Elimination." Part 1. Annex B "Restriction." Part 1.