

Corrected : 08/04/2009

COVER SHEET FOR PROPOSAL TO THE NATIONAL SCIENCE FOUNDATION

PROGRAM ANNOUNCEMENT/SOLICITATION NO./CLOSING DATE <small>if not in response to a program announcement/solicitation enter NSF 09-29</small>					FOR NSF USE ONLY	
NSF 08-553			08/01/09		NSF PROPOSAL NUMBER	
FOR CONSIDERATION BY NSF ORGANIZATION UNIT(S) <small>(Indicate the most specific unit known, i.e. program, division, etc.)</small>					0958095	
SES - SCIENCE, TECH & SOCIETY						
DATE RECEIVED	NUMBER OF COPIES	DIVISION ASSIGNED	FUND CODE	DUNS# <small>(Data Universal Numbering System)</small>	FILE LOCATION	
08/03/2009	2	04050000 SES	7603	010379790	08/04/2009 7:46pm	
EMPLOYER IDENTIFICATION NUMBER (EIN) OR TAXPAYER IDENTIFICATION NUMBER (TIN)		SHOW PREVIOUS AWARD NO. IF THIS IS <input type="checkbox"/> A RENEWAL <input type="checkbox"/> AN ACCOMPLISHMENT-BASED RENEWAL		IS THIS PROPOSAL BEING SUBMITTED TO ANOTHER FEDERAL AGENCY? (b) (4)		
816001713						
NAME OF ORGANIZATION TO WHICH AWARD SHOULD BE MADE			ADDRESS OF AWARDEE ORGANIZATION, INCLUDING 9 DIGIT ZIP CODE			
University of Montana			University of Montana			
AWARDEE ORGANIZATION CODE (IF KNOWN)			ORSP			
0025361000			Missoula, MT. 598124104			
NAME OF PERFORMING ORGANIZATION, IF DIFFERENT FROM ABOVE			ADDRESS OF PERFORMING ORGANIZATION, IF DIFFERENT, INCLUDING 9 DIGIT ZIP CODE			
PERFORMING ORGANIZATION CODE (IF KNOWN)						
IS AWARDEE ORGANIZATION (Check All That Apply) <small>(See GPG II.C For Definitions)</small>		<input type="checkbox"/> SMALL BUSINESS <input type="checkbox"/> FOR-PROFIT ORGANIZATION		<input type="checkbox"/> MINORITY BUSINESS <input type="checkbox"/> WOMAN-OWNED BUSINESS		<input type="checkbox"/> IF THIS IS A PRELIMINARY PROPOSAL THEN CHECK HERE
TITLE OF PROPOSED PROJECT The Ethics of Geoengineering: Investigating the Moral Challenges of Solar Radiation Management						
REQUESTED AMOUNT \$ (b) (4)	PROPOSED DURATION (1-60 MONTHS) 20 months	REQUESTED STARTING DATE 06/01/10	SHOW RELATED PRELIMINARY PROPOSAL NO. IF APPLICABLE			
CHECK APPROPRIATE BOX(ES) IF THIS PROPOSAL INCLUDES ANY OF THE ITEMS LISTED BELOW						
<input type="checkbox"/> BEGINNING INVESTIGATOR (GPG I.G.2)		<input type="checkbox"/> HUMAN SUBJECTS (GPG II.D.7) Human Subjects Assurance Number _____				
<input type="checkbox"/> DISCLOSURE OF LOBBYING ACTIVITIES (GPG II.C.1.e)		Exemption Subsection _____ or IRB App. Date _____				
<input type="checkbox"/> PROPRIETARY & PRIVILEGED INFORMATION (GPG I.D, II.C.1.d)		<input type="checkbox"/> INTERNATIONAL COOPERATIVE ACTIVITIES: COUNTRY/COUNTRIES INVOLVED (GPG II.C.2.j)				
<input type="checkbox"/> HISTORIC PLACES (GPG II.C.2.j)		_____				
<input type="checkbox"/> EAGER* (GPG II.D.2) <input type="checkbox"/> RAPID** (GPG II.D.1)		<input type="checkbox"/> HIGH RESOLUTION GRAPHICS/OTHER GRAPHICS WHERE EXACT COLOR REPRESENTATION IS REQUIRED FOR PROPER INTERPRETATION (GPG I.G.1)				
<input type="checkbox"/> VERTEBRATE ANIMALS (GPG II.D.6) IACUC App. Date _____		PHS Animal Welfare Assurance Number _____				
PI/DP DEPARTMENT The Center for Ethics		PI/DP POSTAL ADDRESS 32 CAMPUS DRIVE MAIN HALL				
PI/DP FAX NUMBER 406-243-6633		MISSOULA, MT 598120001 United States				
NAMES (TYPED)	High Degree	Yr of Degree	Telephone Number	Electronic Mail Address		
PI/DP NAME N. Dane Scott	PhD	(b) (6)	406-243-6671	dane.scott@mso.umt.edu		
CO-PI/DP Christopher J Preston	PhD	(b) (6)	406-243-6671	christoper.preston@mso.umt.edu		
CO-PI/DP Laurie Yung	DPhil	(b) (6)	406-243-6671	laurie.yung@umontana.edu		
CO-PI/DP						
CO-PI/DP						

CERTIFICATION PAGE

Certification for Authorized Organizational Representative or Individual Applicant:

By signing and submitting this proposal, the Authorized Organizational Representative or Individual Applicant is: (1) certifying that statements made herein are true and complete to the best of his/her knowledge; and (2) agreeing to accept the obligation to comply with NSF award terms and conditions if an award is made as a result of this application. Further, the applicant is hereby providing certifications regarding debarment and suspension, drug-free workplace, and lobbying activities (see below), nondiscrimination, and flood hazard insurance (when applicable) as set forth in the NSF Proposal & Award Policies & Procedures Guide, Part I: the Grant Proposal Guide (GPG) (NSF 09-29). Willful provision of false information in this application and its supporting documents or in reports required under an ensuing award is a criminal offense (U. S. Code, Title 18, Section 1001).

Conflict of Interest Certification

In addition, if the applicant institution employs more than fifty persons, by electronically signing the NSF Proposal Cover Sheet, the Authorized Organizational Representative of the applicant institution is certifying that the institution has implemented a written and enforced conflict of interest policy that is consistent with the provisions of the NSF Proposal & Award Policies & Procedures Guide, Part II, Award & Administration Guide (AAG) Chapter IV.A; that to the best of his/her knowledge, all financial disclosures required by that conflict of interest policy have been made; and that all identified conflicts of interest will have been satisfactorily managed, reduced or eliminated prior to the institution's expenditure of any funds under the award, in accordance with the institution's conflict of interest policy. Conflicts which cannot be satisfactorily managed, reduced or eliminated must be disclosed to NSF.

Drug Free Work Place Certification

By electronically signing the NSF Proposal Cover Sheet, the Authorized Organizational Representative or Individual Applicant is providing the Drug Free Work Place Certification contained in Exhibit II-3 of the Grant Proposal Guide.

Debarment and Suspension Certification

(If answer "yes", please provide explanation.)

Is the organization or its principals presently debarred, suspended, proposed for debarment, declared ineligible, or voluntarily excluded from covered transactions by any Federal department or agency?

(b) (4)

By electronically signing the NSF Proposal Cover Sheet, the Authorized Organizational Representative or Individual Applicant is providing the Debarment and Suspension Certification contained in Exhibit II-4 of the Grant Proposal Guide.

Certification Regarding Lobbying

The following certification is required for an award of a Federal contract, grant, or cooperative agreement exceeding \$100,000 and for an award of a Federal loan or a commitment providing for the United States to insure or guarantee a loan exceeding \$150,000.

Certification for Contracts, Grants, Loans and Cooperative Agreements

The undersigned certifies, to the best of his or her knowledge and belief, that:

- (1) No federal appropriated funds have been paid or will be paid, by or on behalf of the undersigned, to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with the awarding of any federal contract, the making of any Federal grant, the making of any Federal loan, the entering into of any cooperative agreement, and the extension, continuation, renewal, amendment, or modification of any Federal contract, grant, loan, or cooperative agreement.
- (2) If any funds other than Federal appropriated funds have been paid or will be paid to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with this Federal contract, grant, loan, or cooperative agreement, the undersigned shall complete and submit Standard Form-LLL, "Disclosure of Lobbying Activities," in accordance with its instructions.
- (3) The undersigned shall require that the language of this certification be included in the award documents for all subawards at all tiers including subcontracts, subgrants, and contracts under grants, loans, and cooperative agreements and that all subrecipients shall certify and disclose accordingly.

This certification is a material representation of fact upon which reliance was placed when this transaction was made or entered into. Submission of this certification is a prerequisite for making or entering into this transaction imposed by section 1352, Title 31, U.S. Code. Any person who fails to file the required certification shall be subject to a civil penalty of not less than \$10,000 and not more than \$100,000 for each such failure.

Certification Regarding Nondiscrimination

By electronically signing the NSF Proposal Cover Sheet, the Authorized Organizational Representative is providing the Certification Regarding Nondiscrimination contained in Exhibit II-6 of the Grant Proposal Guide.

Certification Regarding Flood Hazard Insurance

Two sections of the National Flood Insurance Act of 1968 (42 USC §4012a and §4106) bar Federal agencies from giving financial assistance for acquisition or construction purposes in any area identified by the Federal Emergency Management Agency (FEMA) as having special flood hazards unless the:

- (1) community in which that area is located participates in the national flood insurance program; and
- (2) building (and any related equipment) is covered by adequate flood insurance.

By electronically signing the NSF Proposal Cover Sheet, the Authorized Organizational Representative or Individual Applicant located in FEMA-designated special flood hazard areas is certifying that adequate flood insurance has been or will be obtained in the following situations:

- (1) for NSF grants for the construction of a building or facility, regardless of the dollar amount of the grant; and
- (2) for other NSF Grants when more than \$25,000 has been budgeted in the proposal for repair, alteration or improvement (construction) of a building or facility.

AUTHORIZED ORGANIZATIONAL REPRESENTATIVE		SIGNATURE	DATE
NAME Laura Plute		Electronic Signature	Aug 3 2009 6:03PM
TELEPHONE NUMBER (b) (6)	ELECTRONIC MAIL ADDRESS laura.plute@umontana.edu	FAX NUMBER 406-243-5739	

* EAGER - EARly-concept Grants for Exploratory Research

** RAPID - Grants for Rapid Response Research

The Ethics of Geoengineering: Investigating the Moral Challenges of Solar Radiation Management

In 2006, Nobel Prize winning chemist Paul Crutzen startled the scientific world with a paper in *Climatic Change* arguing that geoengineering the climate can buy some critical time while carbon emissions are curbed and that we should no longer postpone serious research on geoengineering. Since then, discussion of geoengineering is increasingly part of the scientific and public debate over climate change.

This project focuses on the subset of geoengineering technologies that manipulate solar radiation (or enhance albedo). Because such proposals involve manipulation of the natural world at an unprecedented scale and may involve significant risk and uncertainty, they raise important, challenging ethical issues. Should humans take intentional control of the climate? What level of risk of unintended consequences is acceptable? Given the uneven nature of the winners and losers, would the potential benefits to any one group be allowed to trump the potential harms to another? Does geoengineering distract from important mitigation tasks? **The overarching goal of this project is to make significant and lasting contributions to deliberations over the ethics of solar radiation management (SRM).**

Intellectual Merit

The ethics of geoengineering was recently described by a leading climate change ethicist as “uncharted waters.” This project will be exploring new ground and making original contributions regarding how we might, in the context of deliberate manipulation of solar radiation, think about questions of social and procedural justice, the role of technology in solving environmental problems, increasing manipulation of the natural world, risk and uncertainty, and public trust in science. Our approach to these questions will be interdisciplinary, combining philosophical and social science research, guided by leading geoengineers, climate scientists, and policy experts. Interviews with a diversity of stakeholders from around the world will be integrated with ethical research to produce an analysis of the ethical issues that the global community needs to address prior to any geoengineering decision.

Broader Impacts

Despite growing interest in geoengineering and expanded funding for scientific research, there is currently a paucity of intellectual resources available to provide a foundation for public debate over the ethics of geoengineering. To the best of our knowledge, there has been no detailed ethical analysis, nor any social science research focusing on this topic, no book illuminating the debate for a broader audience, and no single online resource center with information on the ethical issues. This project provides a critical and timely contribution by starting to build these much-needed resources. The project involves:

- an **advisory panel of experts** in geoengineering, climate science, and policy.
- a three day **workshop** on geoengineering at the University of Montana, including top scientists, graduate students, law and policy experts, and ethicists.
- **social science research** examining the views of a diversity of stakeholders from both politically powerful *and* marginalized populations on issues of equity, risk, and vulnerability.
- **ethical analysis** of the key moral challenges associated with geoengineering proposals.
- **journal articles** for multiple audiences and a **book**, written for a broad audience, containing a systematic analysis of the ethical issues arising from a range manage solar radiation.
- an **interactive on-line resource center** intended to become the definitive international site.

The interweaving of ethics, biophysical science, and social science analysis in this project will result in products that are grounded in the very real ethical concerns that must be addressed if the global community is to consider taking the unprecedented step of intentionally engineering the climate.

TABLE OF CONTENTS

For font size and page formatting specifications, see GPG section II.B.2.

	Total No. of Pages	Page No.* (Optional)*
Cover Sheet for Proposal to the National Science Foundation		
Project Summary (not to exceed 1 page)	1	_____
Table of Contents	1	_____
Project Description (Including Results from Prior NSF Support) (not to exceed 15 pages) (Exceed only if allowed by a specific program announcement/solicitation or if approved in advance by the appropriate NSF Assistant Director or designee)	14	_____
References Cited	5	_____
Biographical Sketches (Not to exceed 2 pages each)	6	_____
Budget (Plus up to 3 pages of budget justification)	6	_____
Current and Pending Support	4	_____
Facilities, Equipment and Other Resources	2	_____
Special Information/Supplementary Documentation	0	_____
Appendix (List below.) (Include only if allowed by a specific program announcement/ solicitation or if approved in advance by the appropriate NSF Assistant Director or designee)	_____	_____
Appendix Items:		

*Proposers may select any numbering mechanism for the proposal. The entire proposal however, must be paginated. Complete both columns only if the proposal is numbered consecutively.

The Ethics of Geoengineering: Investigating the Moral Challenges of Solar Radiation Management

Project Justification

[Geoengineering has] “got to be looked at. We don’t have the luxury of taking any approach off the table.”
- John Holdren, Science Advisor to President Obama, 8th April, 2009

“Coordinated study of historical, ethical, legal, and social implications of geoengineering that integrates international, interdisciplinary, and intergenerational issues and perspectives...”
- American Meteorological Society recommendation, 20th July, 2009

Over the last 18 months, geoengineering has garnered increasing attention in the popular and scientific media as a potential means for combating the effects of global climate change (*Guardian* 2009, *Science Daily* 2009, *Atlantic Monthly* 2009, *The Economist* 2008, *Time Magazine* 2008, *Scientific American* 2008, *Philosophical Transactions of the Royal Society* 2008, *National Science Foundation News* 2008). Launder and Thompson (2008) succinctly captured the reason for the recent interest. "While such geoscale interventions may be risky," they wrote, "the time may well come when they are accepted as less risky than doing nothing..."

In 2006, Nobel Prize winning chemist Paul Crutzen (2006) startled the scientific world with a paper in *Climatic Change* arguing that we should no longer postpone serious research on geoengineering. Crutzen claimed that geoengineering could buy some critical time while carbon emissions are curbed. His paper almost single-handedly changed the image of geoengineering from an unhelpful distraction to a potentially important climate strategy. "Thanks to Crutzen’s stature..." a recent article in *Science* noted "...scientific and ethical debate is blossoming as the climate community begins to take a hard look at geoengineering the climate" (Kerr 2006).

David Keith defines geoengineering as "the intentional *large-scale* manipulation of the environment, particularly manipulation that is intended to reduce undesired anthropogenic climate change" (Keith 2002). Numerous schemes, ranging from massive reforestation projects to sequestration of carbon at coal-fired power plants, to cloud brightening, to the deployment of space mirrors, have all been called geoengineering. Geoengineering proposals generally fall into two categories, solar radiation management (SRM) and carbon sequestration. *This project focuses on the subset of geoengineering technologies that manipulate solar radiation (albedo enhancement) on a large scale because these technologies raise more significant and pressing ethical issues.* Managing solar radiation on a large scale is an unprecedented intentional manipulation of natural systems. It is here that some of the most complex social and ethical questions can be found, questions about social and procedural justice, the role of technology in society, risk and uncertainty, and public trust in science. And it is here that the global community is currently least prepared for the ethical challenges. This project will help meet these challenges by investigating the ethical issues associated with the most currently viable technologies for solar radiation management (SRM).

Until Crutzen’s article, discussion of SRM had generally been kept in the shadows, initially because the proposed schemes had been thought too fanciful. As the urgency of doing something about climate change has increased, the discussion of SRM has been growing, but remains on the sidelines due to the “moral hazard” it is thought to create. The hazard is that the acceptance of SRM as a viable technical strategy for combating climate change may reduce the political will to address the root causes of the problem, thereby allowing carbon emissions to continue to climb (and allowing problems such as ocean acidification to continue). On the other hand, advocates of serious geoengineering research counter that the potential harms caused by runaway warming are so severe that “prudence demands that we consider what we might do in the face of unacceptable climate damage” (Caldeira 2008). But even the most enthusiastic advocates acknowledge the fact that geoengineering raises “serious ethical

consideration[s]” (Bunzl 2008). In addition to the moral hazard, numerous, troubling ethical questions remain. Should humans deliberately take control of the climate? What level of risk of unintended consequences is acceptable? Given the uneven nature of the winners and losers, would the potential benefits of geoengineering to any one group be allowed to trump the potential harms to another? How can decisions about geoengineering be fair and just?

A number of these ethical questions have been raised in discussion of SRM (Schneider 1996, Jamieson 1996a, Michaelson 1998, Gardiner 2007b, Bunzl 2008, Robock 2008a and b, Schneider 2008), but there have been no detailed, systematic attempts to answer them. More importantly, despite the pressing social justice issues of participation, democratic decision-making, and the uneven distribution of benefits and harms raised by the prospect of intentionally altering the global commons, there has been little attempt to mesh these moral concerns with any kind of research on what different populations across the globe actually think would be a fair way to proceed. Risky as the prospect of geoengineering may be, refusing to discuss geoengineering risks a different moral hazard; namely, a rushed, uninformed, and undemocratic decision-making process. As public debates over biotechnology and nanotechnology have made evident, when the ethics of major transformational technologies are contentious, it is in nobody’s interest to ignore them.

Our project is designed to help lay the groundwork for deliberation over the ethics of SRM, creating an ethical framework within which informed discussion can take place. This means including the views of populations typically underrepresented in decisions about directions for science and technology. Through a combination of ethical analysis and social science research informed by a panel of expert scientific, legal, and policy advisors, this project is designed to help provide a more complete understanding of the moral factors involved in the decision to say “yes” or to say “no” to geoengineering.

Project Goals and Objectives

The overarching goal of this project is to make significant and lasting contributions to contemporary deliberations over the ethics of SRM. We will fulfill this goal by:

- 1) Conducting in-depth, interdisciplinary research aimed at identifying, examining, and explaining the ethical questions geoengineering raises and discussing possible answers to these questions.
 - This research will lead to **a book and three scholarly articles** aimed at interdisciplinary audiences, including scientists, policymakers, philosophers, students, and the interested public.
- 2) Engaging graduate students, researchers, policy experts, NGOs, and the public in a dialogue about the ethics of geoengineering, pursuing this objective through:
 - A major **workshop** at the University of Montana, including top scientists, graduate students, policy-makers, legal scholars, ethicists, and the public.
 - **An interactive on-line resource center** containing information on the most viable projects in geoengineering and the relevant ethical issues.
- 3) Investigating the question of how people from a diversity of regions around the world consider the ethical issues raised by geoengineering:
 - **Social science research** that includes in-depth interviews with a diversity of stakeholders in both politically powerful regions (the U.S. and Europe) and vulnerable and marginalized regions (Sub-Saharan Africa, low-lying Pacific Islands, and Arctic indigenous communities) about equity, risk, and vulnerability and about how a decision-making process might be crafted that is fair and just.

Relevance to Science Technology and Society Program (STS)

Our proposed 2-year, Collaborative Research project, led by a team of two philosophers and a social scientist, and guided by a senior climate change scientist and a panel of scientific, legal, and policy advisors, will lay the foundation for a more informed discussion of the ethics of SRM. This activity is

located primarily in the Studies of Ethics and Values in Science, Engineering, and Technology (EVS), the Social Studies of Science, Engineering, and Technology (SSS), and the Studies of Policy, Science, Engineering, and Technology (SPS) areas of STS. It also includes elements relevant to the Ethics Education for Graduate Students in Science and Engineering (EESE) program. In the course of studying the ethical issues associated with SRM, the project will pursue significant questions in four areas. First, it will illuminate the tensions between the particular values and norms championed by those who advocate for geoengineering and the values and norms of those who seek alternative solutions to the climate crisis, with attention to race, ethnicity, and gender. We will reveal the moral dimensions hidden within the question of who gets to set the parameters for the debate over SRM (EVS). Second, our social science research will determine how different groups frame the prospect of geoengineering based upon their views on risk and vulnerability, technology and the manipulation of nature, justice and equity, and democratic decision-making. This research will further understanding of the concerns of stakeholders in different regions of the world on the relationship between science/technology and society, knowledge that is critical to the debate about whether or not to move ahead with SRM (SSS). Third, it is clear that any decision about whether or not to pursue SRM provides a good case study for how science, technology, and society can shape each other. Our project will illuminate the reciprocal relationship between policy choices and knowledge production in this arena, demonstrating how a commitment to research can itself become a powerful agent of social change (SPS). Finally, the project will use the research areas above, coupled with an intensive three-day workshop for scientists, ethicists, policy experts, and graduate students, to generate materials for a comprehensive online resource center and a graduate level, short-course on the ethics of geoengineering (EESE).

Intellectual Merits

Research into the ethics of SRM pushes social and ethical inquiry in new and challenging directions. A national expert in the ethics of climate change recently characterized the ethics of geoengineering as “very uncharted waters.”¹ Because of the lack of systematic research in this area it is no hyperbole to say that our project will be exploring new ground and making original contributions. But more uniquely, our approach will be interdisciplinary, combining philosophical and social science research, guided throughout by leading scientific, legal, and policy information.

With the global community now more committed to the urgency of tackling climate change than ever before, the debate over geoengineering has monumental practical import. The expected impacts of SRM on the global commons pushes many of the ethical and philosophical questions about the relationship between science, technology, and environment beyond any familiar boundaries. We intend to evaluate the ethical challenges associated with a range of SRM technologies and proposals (specific researchers and labs are identified below). We are currently planning to include 1) stratospheric aerosol deployment, 2) space-based reflectors, 3) marine cloud brightening, and 4) large-scale terrestrial albedo modification (these four types of technologies are also collectively known as albedo enhancers – see Victor et al 2009). While we intend to focus on those technologies believed to be most viable, we recognize that this is a fast changing field, with new technologies creating excitement or being scientifically challenged in quick succession. At the inception of the project, we will consult with our science advisors (see details on Panel of Expert Advisors below) to finalize this list and ensure that the most viable SRM technologies are included. While different geoengineering proposals create somewhat distinct ethical challenges, all of the above technologies modify solar radiation at an unprecedented scale and may involve significant risk. These proposals depend on the specialized knowledge of a relatively small group of scientists, and thus raise significant ethical questions about global decision-making. For example, stratospheric aerosol deployment raises concerns about the uneven effect on human populations, ozone damage caused by the sulphates, regional changes in plant productivity, and the geo-political conditions required to manage aerosol levels over the long term (Brovkin et al 2009, Robock et al 2008).

We believe that comparisons over a range of SRM technologies will serve to best illuminate the particular ethical challenges of different proposals *and* large-scale geoengineering more generally.

To help bring focus to questions concerning science, technology, and society, the project will look at the following five challenges in depth.

1) Questions of Social, Procedural, and Environmental Justice: SRM takes us into uncharted waters in social, procedural, and environmental justice. Since the effects of the intentional management of the climate are usually global, the whole of earth's population (and all future generations) have a direct stake in the deliberation about whether and how to proceed. From a procedural standpoint, how might the global community make the decision about the most appropriate type of project to pursue and who would be consulted before initiating it (Jamieson 1996a)? From a social justice standpoint, who ought to pay for development and implementation of the technology and who bears responsibility for any unintended consequences (Keith 2002)? From an environmental justice standpoint, whose harms should geoengineering attempt to alleviate first and who in the end should benefit most? The social science research will uncover, through interviews with stakeholders from around the world, the views of both politically powerful *and* vulnerable and marginalized peoples on these pressing justice questions. The ethical analysis will break new ground by weaving together interview results and traditional principles of justice in order to lay the foundation for the resolution of these issues. Our legal and policy advisors will ensure that our analyses consider the realities and challenges of international law.

2) The Moral Hazard of the Technological Fix: As noted earlier, an important reason geoengineering has been kept in the shadows is that many people concerned about climate change believe it creates a moral hazard. The acceptance of geoengineering, it is argued, will reduce the political will to confront the real causes of climate change. Faith in the ability of technology to solve pressing problems without the need for changes in values varies across populations. Thompson (1997) observes that industrial societies often have a built-in bias in favor of new technologies. In 2001, Bohm and Pfister found that 23% of Americans believed that technology could solve the problem of global warming without major sacrifices. Existing social science research indicates that this enthusiasm for technology influences other behaviors. Grob (1995) found that people with a greater belief in technological progress were less likely to engage in environmentally beneficial behavior, such as energy conservation in their homes. As a counterpoint to this enthusiasm for technology, there is also considerable skepticism about the claim that every problem has a "technological fix." According to Rosner (2004), "The term technological fix is...most often used to describe a quick, cheap fix using inappropriate technology that creates more problems than it solves." Geoengineering is, according to some critics, a classic technological fix of this kind, a solution that neither addresses the root causes of the problem nor comes with any degree of certainty regarding its effectiveness. Such technological fixes are opposed by environmentalists who believe it is morally "wrong to fix one environmental problem by increasing the risk of another" (Tetlock and Oppenheimer 2008). Technological fixes therefore have a deeply contested status. Good science – and public trust in that science (see 5 below) – can obviously play a key role in reducing this tension. Our advisors on climate science will help us evaluate which problems are solved, left unsolved, and even created by specific geoengineering technologies. As we investigate these questions, we will explore the tension between those who think climate change requires a technical solution and those who think it requires a change in moral values. Our social science research will reveal how people's worldviews and ideologies, in particular their faith in technological progress, helps explain their views on geoengineering.

3) Challenges in Environmental Ethics: Geoengineering presents environmental ethics with a staggering challenge. The prospect of intentionally changing the climate flies in the face of a broadly held consensus that increasingly large-scale manipulation of the biosphere to suit human needs has been the source of great environmental harm (White 1967, Routley 1973, Merchant 1980, Norton 1991, Plumwood 2002). While frequently decrying what they call "anthropocentrism," environmental ethicists have

emphasized the need to acknowledge the complexity of the earth's biogeochemical systems, to recognize their value (both in-themselves and for the services they provide), and to learn how to live within those system limits (Rolston 1988, Hardin 1993). Geoengineering appears to take the human relationship to nature in precisely the opposite direction from this consensus, ratcheting up manipulation of nature to unprecedented levels and attempting to re-engineer the system's limits (Jamieson 1996a). Geoengineering thus raises substantial questions for the field of environmental ethics. Under what conditions, if any, is geoengineering ethically justified as the lesser of two evils (Gardiner 2009)? Does geoengineering permanently change the moral landscape in environmental ethics and subsequent environmental decision-making? Does it reveal a fundamental naiveté in the consensus view? The social science research will probe these questions by examining how different people consider the trade-offs between various environmental principles and by discovering the circumstances under which they would be prepared to change their conception of the proper human relationship to the natural world.

4) Risk Management, Precaution, and Scientific Uncertainty: A key feature of deliberations over geoengineering will be how to make ethical decisions in the face of scientific uncertainty. Climate models, although helpful in understanding coarse scale global change, do not provide a perfect understanding of the climate system or accurate predictions of regional change. According to Morton (2007), "Global climate models agree that the world will warm and climate patterns will change as the amount of CO₂ in the atmosphere rises, but they do not agree on the amount of warming or the patterns of change." At this point scientists do not have a full understanding of the downstream effects of *either* unintentional climate change *or* intentional geoengineering of the climate. This makes it impossible to understand all the risks and potential harms involved in a decision to proceed with SRM. Despite these uncertainties, evaluative judgments of geoengineering proposals will have to be made. According to Crutzen (2006), these decisions need to be made sooner rather than later.

Scientific risk management has been advanced as a means to weigh potential benefits against potential harms in order to determine a proper course of action in the context of trade-offs. But, critics of risk management argue, the approach makes the dubious assumption that scientists are in a position to "fully understand the impacts of their activities on the environment and establish levels of insult at which the environment or humans [can] rebound from harm" (Raffensberger and Tickner 1999). Given the complexity of ecological and atmospheric systems, this level of understanding is frequently not attainable (Soulé 2000, Wingspread Statement 1998). The precautionary principle is sometimes offered as an alternative to scientific risk management that better accounts for uncertainty (Gardiner 2007a). Raffensberger and Tickner (1999) note that, "in its simplest formulation, the precautionary principle has a dual trigger: If there is a potential for harm from an activity and if there is uncertainty about the magnitude of impacts or causality, then anticipatory action should be taken to avoid harm." Even though SRM is itself an anticipatory action, it is unclear how it could ever satisfy the precautionary principle given the uncertainty about its effects. At best, the decision to proceed would be based on the judgment that geoengineering is potentially the "lesser of two evils" between runaway climate change and the risk of intentionally manipulating the climate (Crutzen 2006, Gardiner 2007b, 2009). This project will explore how the various schemes for SRM challenge current thinking about risk and precaution. Our panel of expert scientific advisors will provide us with a current understanding of the nature of risk and of uncertainty involved. The legal and policy advisors will help us integrate current thinking about how to make policy decisions in the context of uncertainty. The social science research will combine with the ethical principles to determine the conditions under which different populations might judge geoengineering to be the lesser of two evils.

5) Public Trust in Science: Over the last two decades, the climate change debate has illuminated a major dysfunction at the interface between scientific discourse and public dialogue, a dysfunction that also raises questions for the debate over SRM. Our investigations will scrutinize the relationship between public trust in science and support for solar radiation management. While SRM would likely affect large portions of the global population, it would be performed by a scientific and technological cadre from a

select group of countries. Barber (1983) argues that trust is the expectation that social actors will observe several conditions, including (1) that they will perform their technical roles competently; and, 2) that they will act within a persistent moral order. In order to give their blessing, citizens around the world would need to trust that these scientists know what they are doing and that they are acting in the best interest of the global community. With SRM, it may be difficult for all populations to be confident that scientists were working toward a common global interest. Both climate change and SRM will have uneven affects across the globe. Some countries would receive greater benefits from it than others, and some would be at greater risk of harm. Given competing national and regional interests, how could the public be sure that scientists were pursuing a common global good over narrow, national interests? The scale and potential irreversibility of geoengineering under conditions of scientific uncertainty will likely exacerbate existing anxieties about the role of scientific experts. This project will explore how public trust in science and technology influences views on the acceptability of geoengineering. It will also explore the appropriate relationship between the role of experts and non-experts in public debates about science.

One of the key intellectual merits of this project is the effective integration of biophysical science, social science, and ethical analysis. There are two important elements of this dialogue between disciplines, both critical to the success of this project. First, the integration of biophysical science, and specifically climate science and geoengineering, ensures that the ethical analysis is guided by the realities of current research. Our close collaboration with a panel of expert advisors (details below) ensures that we examine geoengineering proposals and technologies that might actually be considered in the future. In other words, grounding our work in current science prevents abstract, hollow theorizing on scientific advances that are improbable. It also ensures that this investigation considers the latest science on the range of possible impacts of SRM *and* is relevant to public debate and policy-making. Second, the integration of social science and ethical analysis ensures that philosophical discussions are based on real world concerns and issues. The purpose of the social science is to examine the views of a diversity of people from different regions of the world on the ethics of geoengineering *and* to integrate these views into the ethical analysis (details on how integration of social science and ethical analysis will be accomplished can be found on page 10). Since SRM technology has the potential to impact all regions and peoples on earth and since such decisions will be highly politicized in a geopolitical arena where the internationally powerful often dominate the discussion, it is especially important that the concerns of people who are vulnerable to climate change *and* politically and economically marginalized become part of the dialogue. To integrate the views of a diversity of people, will interview geoengineers, *and* policy-makers, community activists, and NGO staff in arctic indigenous communities, low lying Pacific Island nations, sub-Saharan Africa, Western Europe, and the Southwest U.S. (methodological details below). The philosophical ethics in this project will thus be solidly grounded in the views and concerns of people from a range of backgrounds, bringing the ethical analysis out of the ivory tower and into conversation with contemporary public debate. This connection to public debate will help to ensure that our recommendations are not just ethically viable but also politically so. In sum, the ethical analyses will be guided by the social science research, allowing the team to incorporate a variety of stakeholder perspectives into the project. But, because ethics is more than public opinion, the ethical analysis will also be grounded in solid and rigorous ethical theory.

Project Design

Project goals will be advanced through the following activities, each of which are complementary and in dialogue throughout the project.

1) Panel of Expert Advisors

We have convened a panel of 7 experts in geoengineering, climate science, biogeochemistry, ecology, law, and governance (including a senior advisor) to guide our investigation at numerous points in the process (see supplementary documents for letters of support from advisors).

This panel, made up of leading experts from North America, will ensure that the research we do is solidly grounded in the scientific, political, and legal realities. The advisors will help with the following tasks:

- Helping us understand the technical and scientific details of specific geoengineering technologies and ensuring that we focus on the most relevant proposals
- Assisting in the formulation of research questions and study plans
- Advising on workshop design and providing keynote talks at the workshop
- Keeping us up to date on the nature of scientific uncertainty related to climate change and the outcomes and risks associated with geoengineering proposals
- Informing us of relevant international policies, and policy proposals that might be germane to geoengineering proposals
- Providing presubmission reviews of publications
- Making recommendations for the online resource center

In addition to serving on the panel, Steven Running will also serve as our senior advisor. Running is located on the University of Montana campus and will give us continuous science advice, with a focus on solar budgets, global climate models, and uncertainty.

2) Debating Science Workshop on Ethics and Geoengineering

In an effort to stimulate in-depth thought and discussion on the ethics of SRM to help frame and guide our research, as well as to provide an opportunity to educate graduate students on these issues, we will convene a 3-day workshop at The University of Montana. This workshop will build on experience gained in our successful NSF-funded Debating Science workshops. We will invite leading scientists and scholars (see list below) who can help us understand the specific SRM technologies we plan to focus on (like to include marine cloud brightening, stratospheric aerosols, space mirrors, and terrestrial albedo modification) and the legal, political, and ethical aspects of geoengineering. We also plan to recruit ten highly qualified graduate students from across the country to participate. Students will be selected based on their academic qualifications and paper proposals on the topic of ethics and geoengineering. We will actively recruit women and underrepresented groups, including members of regional indigenous American populations. Students invited to attend the workshop will receive one graduate credit for attending the event and writing a follow-up paper. Representatives from local NGOs working on climate related issues will be invited to attend. We plan to invite the following individuals to participate (we plan

to bring up to 5 individuals in addition to our panel of advisors with funds from this budget and resources from the Center for Ethics and the University of Montana visiting scholars programs):

- Science Seminars: Leading experts on the science of SRM from our panel of advisors will provide workshop sessions. In addition to our panel of advisors we will invite additional experts including, Ken Caldeira, Carnegie Institution (atmospheric science, climate change ecology), Paul Crutzen, Max Planck Institute or Tom Wigley, National Center for Atmospheric Research (stratospheric aerosols), John Latham, National Center for Atmospheric Research (cloud brightening), Andrew Ridgwell, University of Bristol, (bio geoengineering), Hashem Ackbari, Lawrence Berkeley National Laboratory (cool roofs).
- Ethics Seminars: Leading legal, policy, and ethics experts from our panel of advisors and the PIs will provide commentaries that complement each science seminar. We will invite additional experts, including Stephen Gardiner, University of Washington (author of “Ethics and Global Climate Change” (2004) and “Is Geoengineering the Lesser Evil?” (2007b)), Dale Jamieson, NYU, Director of Environmental Studies (author of the first ethics article on “Intentional Climate Change” (1996).

In addition to presentations, workshop participants will work together to identify and prioritize the key ethical issues related to SRM management, and provide feedback on the proposed research design. As part of the workshop we will also hold an evening roundtable event that will be free and open to the public. The workshop seminars and the associated roundtable event will be videoed and posted on the online resource center. Short interviews with members of our advisory panel and additional invited experts during the workshop will be put up as podcasts on the online resource center. Information from the workshop will inform the final shape of the syllabus for the one-credit short course on the ethics of geoengineering (see below).

2) Social Science Research on Global Views of Geoengineering

The social science component of this project seeks to understand the concerns and views of people from different regions of the world. More specifically, we plan to interview geo-engineers, and policy-makers, community activists, and the staff of non-governmental organizations (NGOs) working on climate change in different regions of the world. We will interview 48 individuals evenly distributed amongst the following groups: (1) geo-engineers, and residents of (2) arctic indigenous communities in Alaska and Northern Canada, (3) sub-Saharan Africa, (4) low-lying Pacific Islands, (5) Western Europe, and (6) Southwestern U.S.. We have selected these regions for the following reasons: 1) to ensure that the voices and views of people who are vulnerable to climate change *and* politically and economically marginalized are brought into the discussion of geoengineering, 2) to be able to compare and contrast the perspectives of marginalized people with the views of scientists, NGO staff, and policy-makers from Western Europe and the U.S, and 3) to understand both a diversity of views and gain some depth in particular regions of the world. Policy-makers, community activists, and NGO staff will be selected based on their engagement in climate change politics and/or the potential impact of climate change on their work, people, or country. We will seek out local, independent NGOs to ensure that the voices of the poor are represented in the sample to the extent possible (please see details about interview sampling below).


To better understand these diverse perspectives, we will utilize in-depth, semi-structured qualitative interviews guided by an interview guide to ensure comparability and consistency across the interview sample (Charmaz 1991; Patterson and Williams 2002). Interviews allow for exploration of complex ethical and sociopolitical issues. The interview guide will be developed based on the ethical issues identified by the PIs in dialogue with the advisory panel and workshop participants. In addition to questions about the impacts of and solutions to climate change, interview participants will be asked to specifically consider the various ethical dilemmas raised by geoengineering proposals and the politics of geoengineering decisions. The interviews will include exploration of future scenarios to better understand how different climate projections and regional impacts influence how participants consider geoengineering. The researchers will utilize frequent probes to better understand how research

participants are thinking about trade-offs, equity, risk and vulnerability, technology, and democratic decision-making. While interviews will not provide estimates of how views are distributed in a population, we believe that quantitative research in this arena is premature and that interviews provide distinct advantages regarding ability to examine nuances, complexity, and contradiction in depth. The interview format also provides opportunities for research participants to raise issues that were not anticipated by the research team, thus uncovering unexpected, unpredicted phenomena. This is especially important for geoengineering, an area where ethical discussions are just beginning and in which academics and scientists in the industrial world have largely dominated the conversation.

The interview sampling will be purposive (not random), with individuals selected for participation based on specific criteria (their engagement with climate change issues as NGO staff, community activists, or policy-makers in the selected regions). The goal of sampling will be to understand a diversity of views with depth in particular regions of the world. To achieve diversity in the sample, we will include women and men (we will strive for gender balance in the sample), and people from different ethnic groups, political perspectives, and generations. We will also seek out people with diverse views on technology and geoengineering in particular. The interview guide will be pretested with at least five individuals from different parts of the world. An initial list of potential participants will be generated using chain referral techniques (Brandenburg and Carroll, year). Interview participants will then be selected from this list using the criteria outlined above.

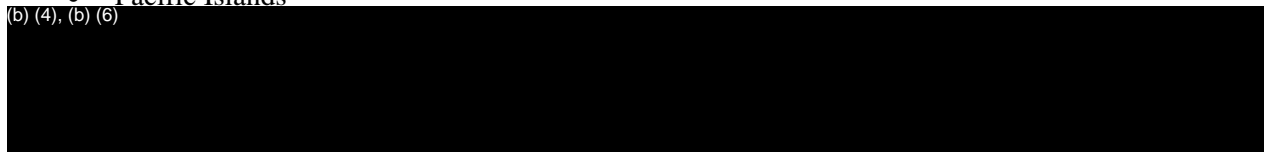
Examples of Potential Interview Participants (Individuals and/or Organizations) by Region

(b) (4), (b) (6)



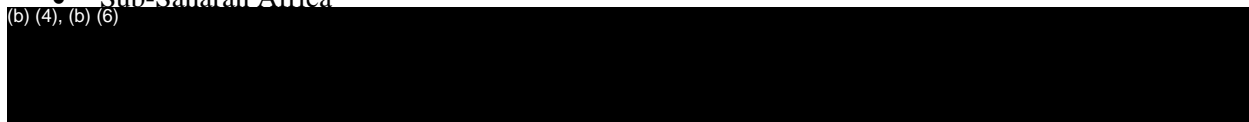
- Pacific Islands

(b) (4), (b) (6)




- Sub-Saharan Africa

(b) (4), (b) (6)



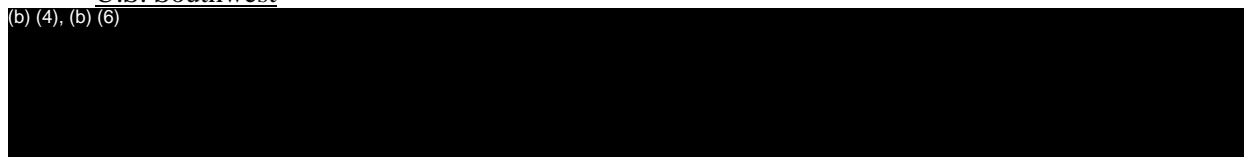
- Western Europe

(b) (4), (b) (6)



- U.S. Southwest

(b) (4), (b) (6)



Interviews will be taped and transcribed verbatim. Individual interviews will be analyzed using a system of open coding followed by detailed across interview analysis and comparison (Fetterman 1998; Patterson and Williams 2002; Corbin and Strauss 2007). Interviews will not be anonymous, as we feel that protecting anonymity is not necessary to obtain frank responses on these issues and that the context within which these individuals emerge is important for understanding their views.

4) Publications for Multiple Audiences

Publications will include peer-reviewed journal articles for ethics, social science, and climate science and policy audiences, and the first book length treatment of the ethics of SRM. Provisional book chapter topics are as follows:

1. Introduction and Definitional Issues.
2. Terrestrial and Low-level Management of Solar Radiation.
3. Stratospheric Management Schemes and Beyond.
4. Views from Around the Globe.
5. Social, Procedural, and Environmental Justice.
6. The Moral Hazard of the Technological Fix.
7. Challenges in Environmental Ethics.
8. Risk Management, Precaution, and Scientific Uncertainty.
9. Public Trust in Science.

With assistance from the panel of scientific advisors, we will provide a balanced account of the promise, the perils, and ethical challenges presented by the various SRM technologies. Workshop discussions and in-depth interviews and in-person visits with geoengineers and other experts will inform the early chapters 1-3. Global views of geoengineering will be examined in chapter 4. Chapters 5-9 will contain the results of our ethical research on the 5 areas of ethical challenge identified above. In the course of the analysis we will show how some of the issues in geoengineering mirror issues in debates over other emerging technologies (for example, justice issues in agricultural biotechnology and public trust in science issues in nanotechnology). We will also show how the degree of intentional manipulation of the global commons in geoengineering intensifies these challenges and presents new ethical dilemmas. The book will be written for a broad audience that includes scientists, ethicists, policy-makers, NGOs, and the interested public.

5) Interactive Online Geoengineering Resource Center

We will create the leading on-line resource center on the ethics of geoengineering to promote public understanding, teaching, learning, and discussion. The online resource center will include:

- A comprehensive bibliography with links to available articles on geoengineering, and specifically on ethics and geoengineering
- Links to the latest projects in geoengineering and the relevant labs
- Links to the latest ethical discussions
- Interview summaries and selected quotes from the social science research
- Videos of workshop presentations
- Podcasts of interviews with experts at our workshop
- A syllabus for teaching a graduate level, short course on ethics and geoengineering
- Links to existing blogs and googlegroups on geoengineering
- Discussion boards for posting comments on different geoengineering proposals
- An online survey tool allowing persons from different global populations to express opinions on various geoengineering proposals and on the ethical issues they create (the results of the survey would be made public on the Web site at the end of the project)

This website will provide the definitive, up-to-date resource on the ethical dimensions of geoengineering.

6) Integrating Social Science and Ethical Analysis throughout the Project

We plan to build in structures and processes that ensure integration between the activities described above, with particular attention to integration of social science and ethical analysis throughout the project. This iterative, dialogic process will occur from project inception through to publications and products, and such dialogue will be accomplished through collaborative planning, design, and analysis with the three PIs and the panel of expert advisors at the following critical junctures: 1) During the

project development phase, initial ethical analysis will be conducted in collaboration with our advisors and workshop participants. This analysis will generate ethical issues and questions which will then inform the research and interview questions that guide the social science research; 2) During data collection and analysis, the social scientist and the philosophers will meet regularly to incorporate the ethical concerns that emerge from the interviews into the broader project and to examine the ways in which people from different regions view geoengineering. Because the format of the interviews allows participants to raise substantive issues and concerns that are not necessarily anticipated by the research team, interview results will influence the framing, prioritization, and discussion of ethical issues in subsequent products and publications. The PIs will also provide a summary of interview results to the panel of expert advisors and seek feedback regarding the interpretation and policy relevance of these results; and 3) During the writing and product development phase, social science research results and selected excerpts from interviews will be used in coauthored journal articles and throughout the book to illustrate viewpoints from around the world and to provide readers with an understanding of the complexity and diversity of perspectives. Interview summaries and quotes will also inform the content for the online resource center.

Broader Impacts

As described at the start of this project description, in the last year geoengineering has increasingly become part of the discussion of how to address climate change. Despite growing interest in SRM, there is a paucity of intellectual resources to provide a foundation for public debate over the ethics of the various schemes. To the best of our knowledge there has been no detailed and comprehensive ethical analysis, nor any social science research focusing on this topic, no single online resource center, no courses on the ethics of SRM, and no book illuminating the debate for a broader audience. This project provides a critical and timely contribution to building these much-needed resources.

1) Advancing discovery and understanding while promoting teaching, training, and learning

This project will result in a range of products that can be used as educational resources in a variety of settings, to promote teaching, training, and learning. The book will be a valuable resource for policy-makers, the public, and for undergraduate and graduate courses on environmental ethics, philosophy of technology, and climate change. The online resource center will provide a valuable educational resource and a forum for learning and deliberation on the social and ethical issues connected to geoengineering. The workshop provides a unique opportunity for faculty, graduate students, scientists, and NGOs to dialogue about the ethical questions raised by geoengineering. By enabling graduate students to interact with expert scientists and ethicists as well as the project team, the workshop will contribute to the goal of building educational resources on the ethics of geoengineering.

Furthermore, this project supports graduate student training in several ways. It provides funding and research opportunities for two graduate students, one in philosophy and one in environmental social science. Graduate students from around the country will participate in the workshop, furthering their training in the ethical issues related to geoengineering.

One of the PIs teaches an upper division course in Climate Change, Ethics, and Policy. A second PI teaches introductory classes in ethics and the environment and a graduate seminar in the philosophy of ecology. The philosophy graduate student will assist where needed in these courses and will conduct research for the book. A short course in the ethics of geoengineering will be created and offered online through the Center for Ethics at the University of Montana.

2) Disseminating results broadly to enhance scientific and technological understanding

This project is specifically designed to engage a broad audience in discussion of geoengineering. The book will be accessibly written for scientists, policy-makers, students, and the general public, tapping into both the technological excitement created by geoengineering and the reasons for opposition. It will be engaging and free of unnecessary technical jargon. We intend to make the online resource center the definitive international site on the ethics of geoengineering. The social science research will advance understanding by uncovering the ethical concerns of diverse groups of people around globe. Because the

workshop will be filmed and posted on-line, in addition to interviews with individual scientists and ethicists who attend the workshop, the material generated will have the potential to engage a broad audience in thoughtful discussion about geoengineering. We will seek to publish papers presented at the workshop in a special issue of an applied ethics journal such as *Techné, Ethics, and the Environment, or Ethics Place, and Environment*. Articles will also be submitted to philosophical, social science, climate science, and international policy journals such as *Environmental Ethics, Ethics and the Environment, Public Affairs Quarterly, Climatic Change, Foreign Affairs, and Society and Natural Resources*. The PIs will also engage the scientific and ethics communities through conference presentations at meetings of the International Society for Environmental Ethics, American Philosophical Association, The Society for Philosophy in the Contemporary World, and the International Symposium on Society and Resource Management, and, where possible, regional, national, and international climate change conferences.

3) Broadening the participation of underrepresented groups

This project investigates the views of a diversity of people around the world, including women (we will strive for gender balance in the social science interview sample) and non-whites from poor and politically marginalized regions of the world (including arctic indigenous communities, and residents of low-lying Pacific Island nations and sub-Saharan Africa). This project is unique in that it integrates the concerns and ideas of people who will be affected by climate change, but whose views are often absent in decision-making circles. We believe that an international dialogue about the ethics of SRM must consider these diverse viewpoints and that we can only ascertain the concerns of people from around the world by talking directly with them. Interview results and excerpts will be integrated into project publications and presented in summary form on the website. Thus, the views and concerns of marginalized and underrepresented groups – women, non-whites, indigenous groups, and residents of developing countries – will be at the core of this project. In the workshop and roundtable events at The University of Montana, we will encourage participation from underrepresented and marginalized groups, including local Native American populations.

4) Enhancing the infrastructure for research and education, such as networks and partnerships

The workshops will build networks and partnerships between faculty, graduate students, NGOs, and scientists who are considering the future of geoengineering. The on-line resource center will provide an internet library of resources for users from around the world. This website will also allow for dialogue and discussion of geoengineering, furthering opportunities for interested parties to network and dialogue. The materials for the one-credit class on the ethics of geoengineering will be made available to interested parties and posted on the on-line resource center. The relationships built with our panel of expert advisors will help us to create further collaborations at additional institutions. For example, one of our panel members, David Kieth, is also an Adjunct Professor at the department of Engineering and Public Policy at Carnegie Mellon, home to the Climate Decision Making Center where they study “the limits in our understanding of climate change, its impacts, and the strategies that might be perused to mitigate and adapt to change.” This expertise in decision-making in the face of uncertainty will be highly relevant to our work on the ethics of SRM.

5) Providing benefits to society as a whole

As described above, the overarching goal of this project is to lay the groundwork for deliberation over SRM by identifying and analyzing important ethical issues. The decision to embark on geoengineering through solar radiation management would be unlike any decision ever made in human history. Such a decision requires serious ethical evaluation and public debate before we reach a point of increased urgency regarding climate change. This project will provide social benefits by creating resources—a book, journal articles, an online resource center—that promote understanding and evaluation of the ethical issues arising from the various schemes under consideration. Our work will provide a foundation for the pending national and international dialogue about SRM, while ensuring that diverse perspectives are included in that dialogue.

Project Timeline

Year 1:

June - August 2010

- Begin collaboration/dialogue with panel of expert advisors
- Develop/design workshop
- Recruit graduate students/research assistants
- Recruit additional experts, stakeholders, and graduate students for workshop

September - December 2010

- Hold workshop
- Finalize research questions/foci
- Initial ethical research/preliminary ethical analysis
- Develop sampling plan and interview guide

January – May 2011

- Conduct interviews/collect data
- Draft introduction, and work on the chapters of book dealing with SRM science

Year 2:

June – August 2011

- Follow-up interviews with scientists and visits to labs not represented at the workshop
- Analyze interview data, dialogue with PIs and expert advisors about preliminary results
- Draft of chapters describing the science of SRM schemes, social justice, and environmental ethics

September – December 2011

- Development phase for on-line resource center
- Draft manuscripts to submit to journals
- Draft of public trust in science, moral hazard, and risk management chapters of book

January – May 2012

- Design and launch of on-line resource center
- Continued work on book chapters and submission to publishers
- Conference presentations
- Finalize of book draft

Principal Investigators

Dane Scott is Director of The Center for Ethics and Associate Professor in the Department of Society and Conservation at The University of Montana. He is also the PI of an NSF, EESE project, Debating Science. This 3-year ethics education project is designed to help graduate students in science and engineering consider the larger ethical dimensions of their research and to become productive participants in public science debates. The Debating Science project focuses on global climate change, agricultural biotechnology, and nanotechnology. Scott became interested in the ethical issues in science by studying the international debate over genetically modified organisms. Since 2001, these studies have produced seven peer-reviewed publications and over a dozen professional presentations in the United States and Europe. The topics covered in these articles and presentations provide the foundation for this activity, as they examine science and public trust, the ethics of risk and precaution, and the use of technology to address social and political problems. In the last several years Scott has developed a strong interest in ethics and global climate change. The Center for Ethics is a cooperating institution in the Ethical Dimensions of Climate Change (EDCC) project directed from The Pennsylvania State University. Scott recently made a presentation as part of an EDCC side event at the United Nations Climate Change Conference in Poznań, Poland. His presentation was on the ethical issues embedded in the Reducing Emissions from Deforestation and Forest Degradation (REDD) initiative. The Center for ethics has sponsored or co-sponsored over a dozen public events on these issues. Scott also teaches the graduate-

level course *Climate Change Ethics and Policy* and is co-chair of a task force that is establishing an interdisciplinary program on climate change at The University of Montana.

Christopher J. Preston is Associate Professor of Philosophy at The University of Montana and a fellow at the Center for Ethics. He teaches classes in ethics, feminist ethics, and environmental ethics. He is the author of two books in environmental philosophy, co-editor of a third, and has published numerous articles in environmental ethics on topics ranging from natural value, to Darwin, to epistemology, philosophy of mind, ecofeminism, and public health. He is currently finishing his work with Dane Scott and a University of Montana geosciences professor on the Debating Science project, providing ethics education for science and engineering graduate students in climate change, agricultural biotechnology, and nanotechnology. In April of 2009, he was the commentator on the first geoengineering paper presented at a national philosophy conference (International Society for Environmental Ethics sessions at the Western APA meetings in Vancouver). He is chair of the nominations committee for the International Society for Environmental Ethics. Preston has worked many summers outside of his academic environment in the fishing, park, and conservation industries in Alaska. Each of these experiences gives him good preparation in how to engage non-philosophers in ethics. He was recently invited to update the environmental ethics chapter in a major environmental science text book and has been interviewed on several radio programs across the country for his most recent book.

Laurie Yung is an environmental social scientist at The University of Montana. She serves as a Research Assistant Professor in the Department of Society and Conservation and as Director of the Wilderness Institute. Her work focuses on the social and political aspects of conservation, in particular how people negotiate and adapt to ecological and environmental change at a variety of scales. She currently co-directs an interdisciplinary project, *Naturalness and Beyond*, examining how climate change and other environmental stressors change the way we think about management intervention in park and wilderness ecosystems (this project will culminate in an edited book published by Island Press in early 2010). Yung has also been working with public lands managers to translate research on public views of climate change and ecological change, and to provide guidance on how managers can engage the public in planning for climate change adaptation. She has extensive experience with qualitative interview techniques and methodology, having conducted and/or supervised more than 250 interviews on six projects in a variety of cultural contexts, including indigenous groups and rural residents of developing countries. Furthermore, Yung has worked with a diversity of stakeholders on a number of participatory research projects to ensure that scientific research can be integrated into on-going community, county, and federal-level projects, demonstrating a commitment to bringing intellectual inquiry into decision-making arenas. As Director of the Wilderness Institute, Yung oversees the definitive on-line resource center for wilderness, www.wilderness.net.

References

- Atlantic Monthly, 2009. "Re-Engineering the Earth" by Graeme Wood (July/Aug). Available at <http://www.theatlantic.com/doc/200907/climate-engineering> (accessed 8/2/09).
- Barber, Benard. 1982, *The Logic and Limits of Trust* (New Brunswick, NJ: Rutgers University Press).
- Bodansky, D. 1996, "May we engineer the climate?" *Climatic Change* **33**, 309–321.
- G. Bohm and H. Pfister. 2001. "Mental Representation of Global Environmental Risks." In Bohm et al., eds., *Environmental Risks*. (Amsterdam: JAI): 1-30
- Brovkin, V., Petoukhov, V., Claussen, M., Bauer, E., Archer, D., and C. Jaeger. 2009. Geoengineering Climate by Stratospheric Sulfur Injections: Earth System Vulnerability to Technological Failure. *Climatic Change*, 243-259.
- Brown, D., Tuana, N., et al. 2006. *White Paper on the Ethical Dimensions of Climate Change*. Rock Ethics Institute, Penn State University, PA.. 40 pgs. Available at (<http://rockethics.psu.edu/climate/whitepaper/whitepaper-intro.shtml>) (retrieved 1/24/09)
- Bruce, Donald. 2002. "Finding a Balance Over Precaution," *Journal of Agricultural and Environmental Ethics* 15(1): 7-16.
- Bunzl, M. 2008. "An Ethical Assessment of Geoengineering," *Bulletin of the Atomic Scientists* 64, 18.
- Caldeira, K. 2008. Testimony to the UK House of Commons Innovation, Universities, Science, and Skills Committee, Nov 10th, 2008. Available at <http://www.publications.parliament.uk/pa/cm200708/cmselect/cmdius/memo/1264/ucm1.pdf> (accessed 7/28/09).
- Carlin, Alan, 2007, "Implementation and Utilization of Geoengineering for Global Climate Change Control," *Sustainable Development Law and Policy*, 7(2): 56-8 (Winter), available at <http://carlineconomics.googlepages.com/CarlinSustainableDevelopment.pdf> (accessed 7/28/09)
- Charmaz, K. 1991. Translating graduate qualitative methods into undergraduate teaching: Intensive interviewing as a case example. *Teaching Sociology*. 19:384–395.
- Cicerone, Ralph J. 2006. "Geoengineering: Encouraging Research and Overseeing Implementation," *Climatic Change* 77, 221-226
- Cicerone, R. J., Elliott, S., and Turco, R. P. 1992. "Global Environmental Engineering" *Nature* 356, 472.
- Commission of European Communities. 2000. *Communication from the Commission on the Precautionary Principle* COM.
- Corbin, J. and A.C. Strauss. 2007. *Basics of qualitative research: Techniques and procedures for developing grounded theory*. Thousand Oaks, CA: Sage Publications.
- Crutzen, Paul J. 2006. "Albedo Enhancement by Stratospheric Sulfur Injections: A Contribution to Resolved a Policy Dilemma?" *Climatic Change*, 77, 211-219.

- Fetterman, D. M. 1998. *Ethnography: Step by step*. Thousand Oaks, CA: Sage Publications.
- Gardiner, Stephen 2001. "The Real Tragedy of the Commons." *Philosophy & Public Affairs* 30, 387-416.
- Gardiner, Stephen. 2004. "Ethics and Global Climate Change." *Ethics* 114 (April): 555-600.
- Gardiner, Stephen. 2007a. "A Core Precautionary Principle." *Journal of Political Philosophy* 14 (1):33-60.
- Gardiner, Stephen. 2007b. "Is Geoengineering the 'Lesser Evil'" *Talking Point* (April 18)(Available at <http://environmentalresearchweb.org/cws/article/opinion/27600>) (retrieved 01/05/09).
- Gardiner, Stephen. 2009. "Is Arming the Future with Geoengineering Really the Lesser of Two Evils." *Climate Ethics: Essential Readings*, edited by S. Caney, H.Shue, D.Jamieson, S.Gardiner, (New York: Oxford University Press)(forthcoming).
- Guardian. 2009. "Obama Climate Adviser Open to Geo-engineering to Tackle Global Warming. Available at <http://www.guardian.co.uk/environment/2009/apr/08/geo-engineering-john-holdren> accessed 7/28/09)
- Grob, A. 1995. "A Structural Model of Environmental Attitudes and Behavior" *Journal of Environmental Psychology*, 15, 209-220.
- Hall, Myrna and Daniel Fagre. 2003. "Model Induced Glacier Change in Glacier National Park (1850-2100)" *Bioscience*, Vol.53, 2, 131-140.
- Hardin, Garret. 1993. *Living Within Limits* (New York: Oxford University Press)
- Jamieson, Dale. 1990. "Managing the Future: Public Policy, Scientific Uncertainty, and Global Warming." In *In Upstream/Downstream: Essays in Environmental Ethics*, edited by D. Scherer (Philadelphia: Temple University Press): 67-89.
- Jamieson, Dale. 1991. "The Epistemology of Climate Change: Some Morals for Managers." *Society and Natural Resources* 4, 319-29.
- Jamieson, Dale. 1992. "Ethics, Public Policy and Global Warming." *Science, Technology and Human Values* 17, 139-53.
- Jamieson, Dale. 1996a. "Ethics and International Climate Change," *Climatic Change*, 33: 323-336.
- Jamieson, Dale. 1996b. "Scientific Uncertainty and the Political Process." *Annals of the American Academy of Political and Social Science* 545, 35-43.
- Jamieson, Dale. 2001. "Climate Change and Global Environmental Justice." In *Changing the Atmosphere: Expert Knowledge and Global Environmental Governance*, edited by P. Edwards and C. Miller (Cambridge: MIT Press): 287-307.
- Keith, David W. 2002. "Geoengineering." *Encyclopedia of Global Change*, edited by A.S.Goodie (New York: Oxford University Press): 495-502.

Kerr, Richard A. 2006. "Pollute the Planet for the Climate's Sake?" *Science* Vol. 314, (October 20): 401-403

Lauder, Brian and Michael Thompson. 2008. "Introduction" *Philosophical Transactions of the Royal Society A: Mathematical, Physical, and Engineering Sciences* 366 (1882): 3841-3842.

Marx, L. 1983. "Are Science and Society Going in the Same Direction?" *Science, Technology, and Human Values*, Vol. 8, No. 4, could not find

Merchant, Carolyn. 1980. *The Death of Nature: Women, Ecology, and the Scientific Revolution* (San Francisco: Harper Collins)

Michaelson, Jay. 1998. "Geoengineering: A Climate Change Manhattan Project" 17 (1) *Stanford Environmental Law Journal*, (January): 73-140.

National Science Foundation News. 2008. "Injecting Sulfate Particles into Stratosphere Could Have Drastic Impact on Earth's Ozone Layer" (Available at http://www.nsf.gov/news/news_summ.jsp?cntn_id=111467) (Retrieved 01/11/09)

Norton, Bryan. 1991. *Towards Unity Amongst Environmentalists* (New York: Oxford University Press).

Patterson, M. E. and D. R. Williams. 2002. *Collecting and analyzing qualitative data: Hermeneutic principles, methods, & case examples*. Champaign, IL: Sagamore.

Plumwood, Val. 2002. *Environmental Culture* (New York: Routledge)

Raffensperger, Caryolyn and Joel Tickner, Eds. 1999. *Protecting Public Health and the Environment: Implementing The Precautionary Principle*, (San Francisco: Island Press)

Robock, Alan. 2008. "Geoengineering: It's not a panacea," *Geotimes*, vol. 53: 58.

Robock, Alan. 2008. "Whither Geoengineering?" *Science*, vol. 320, (May 30):1166-1167.

Robock, A., Oman, L. and Stenchikov, G.L. 2008. Regional Climate Responses to Geoengineering with Tropical and Arctic SO₂ Injections. *Journal of Geophysical Research*.

Rolston, Holmes, III. 1988. *Environmental Ethics: Duties to and Values in the Natural World*. (Temple University Press: Philadelphia, PA)

Rosner, Lisa, Ed. 2004. *The Technological Fix, How People Use Technology to Create and Solve Social Problem* (New York: Routledge).

Routley, Richard. 1973. "Is there a Need for a New, an Environmental Ethic?" *Proceedings of the XVth World Congress of Philosophy* 1: 205-210.

Schneider, Stephen. 1996. "Geoengineering: Could - or Should - We Do It?" *Climatic Change* 33: 291-295.

Schneider, Stephen. 2008. "Geoengineering: Could we, or should we, make it work?" *Philosophical Transactions of the Royal Society A* 366: 3842-3863.

Science Daily. 2009. "Geoengineering Climate Requires More Research, Cautious Consideration And Appropriate Restrictions." American Meteorological Society Statement. Available at: <http://www.sciencedaily.com/releases/2009/07/090721135559.htm> (accessed 7/27/09).

Scott, Dane, 2005 "Perspectives on Precaution: the Role of Policymakers in Dealing with the Uncertainties of Agricultural Biotechnology." *International Journal of Global Environmental Issues*, Volume 5 Nos. 1/2 2005

Shrader-Frechette, Kristen. 2002. *Environmental Justice, Creating Equality, Reclaiming Democracy* (New York: Oxford University Press).

Shrader-Frechette, Kristen. 1996. "Methodological Rules for Four Classes of Scientific Uncertainty." In *Scientific Uncertainty and Environmental Problem Solving*, edited by John Lemmons (Cambridge: Blackwell Scientific Press): 12-39.

Shue, Henry. 1992. "The Unavoidability of Justice." In *The International Politics of the Environment*, edited by Hurrell, Andrew and Kingsbury, Benedict. Oxford: Oxford University Press): 373-397.

Shue, Henry. 1995. "Equity in an International Agreement on Climate Change." In *Equity and Social Considerations Related to Climate Change*. Edited by R. S. Odingo, A. L. Alusa, F. Mugo, J. K. Njihia and A. Heidenreich (Nairobi: ICIPE Science Press): 385-392.

Shue, Henry. 1996. "Environmental Change and the Varieties of Justice." In *Earthly Goods: Environmental Change and Social Justice*, edited by Hampson Fen Osier and Reppy Judith (Ithaca, N.Y.: Cornell University Press): 9-29.

Shue, Henry. 1999. "Global Environment and International Inequality." *International Affairs* 75, 531-545.

Soule, Edward. 2000. Assessing the Precautionary Principle. *Public Affairs Quarterly* 14, 309–328.

Sunstein, Cass. 2000. *Laws of Fear: Beyond the Precautionary Principle*, (Cambridge: Cambridge University Press)

Teich, A. H. ed., 1993) *Technology and the Future*, Sixth Edition (New York: St. Martin's Press).

Tetlock, P.E. and M. Oppenheimer. 2008. The boundaries of the thinkable. *Daedalus*, p 59-70.

Thompson, Paul. 1997. *Food Biotechnology in Ethical Perspective* (London: Blackie Academic & Professional).

Victor, D.G., Morgan, M.G., Apt, J., Steinbruner, J. and K. Ricke. 2009. The Geoengineering Option: A Last Resort Against Global Warming? *Foreign Affairs*, 1-5.

Van Den Belt, Henk & Bart Gremmen, "Between Precautionary Principle and 'Sound Science': Distributing the Burdens of Proof," 15 *Journal of Agricultural and Environmental Ethics* 107 (2002).

Volti, R. 1995. *Society and Technological Change*, Third Edition (New York: St. Martin's Press).

White, Lynn. 1967. "The Historical Roots of Our Ecologic Crisis" *Science* 155 (3767): 1203-1207.

Wingspread Statement. 1998. "The Precautionary Principle." Available at <http://www.psrast.org/precaut.htm> (accessed January 25, 2009).