# Interdisciplinary Undergraduate Climate Change Studies Minor for the University of California, San Diego

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**Abstract**

Scientists around the world agree that anthropogenic global warming, with associated climate and ocean change, grew through the Industrial Revolution and will continue. Researchers from Scripps Institution of Oceanography at the University of California, San Diego are globally recognized for their studies on the climate system, the anthropogenic influences on climate, and the implications of these impacts on future generations. As such, UC San Diego is a logical place for undergraduate students, with a desire to pursue research or careers in this field, to explore interests in climate change studies, to design and innovate solutions, or simply become more informed and engaged on the issue. To this end, an interdisciplinary minor in Climate Change Studies was established and should become available for enrollment Winter 2019. Undergraduates in this minor will develop knowledge of climate change science, understanding of the human and social dimensions of climate change, and have opportunities to develop and implement solutions. The curriculum for the minor builds on mostly existing courses across a wide range of departments and programs on campus in addition to the creation of a few, new, applied-learning courses.

**Introduction**

Climate change is arguably the most important social, economic, scientific, and political issue of our time (IPCC 2014, Jamelske et al. 2013, Maibach et al. 2009, Moser 2010, Sterman 2011). Despite the incontrovertible science demonstrating the anthropogenic causes of modern global warming, and the subsequent climatic changes, there are many who do not know or understand the basics of this critical issue (Howe et al. 2015, IPCC 2014, Maibach et al. 2009, Leiserowitz et al. 2018, Weber and Stern 2011). This is due, in part, to the complexity of the issue and the motivated disinformation campaign lead by fossil-fuel interests that face significant losses as progressive changes toward renewable energy are enacted (Hess and Collins 2018, Linden et al. 2017, Moser 2010, Weber and Stern 2011). As noted by Moser (2010), "…those with significant interest in maintaining the fossil-fuel intensive status quo have deliberately created a public perception of a lack of scientific consensus and greater uncertainty about the extent and causes of modern climate change…" In an effort to share the true science of climate change and to stimulate action to mitigate and adapt to its impacts, much work has been done in the last 20 years to learn the most effective means of climate change education and communication. UCSD's greatest influence in responding to climate change in the near future could be through this adjustment to how the University educates students.

## Background

*Climate Change Education*

Despite the disinformation campaign, the majority of Americans do, in fact, believe that climate change is happening (70%) and that humans are the cause (58%) (Maibach et al. 2009, Howe et al. 2015, Leiserowitz et al. 2017, Leiserowitz et al. 2018). A poll of adults (18+) showed that a national average of 77% agree that "schools [K-12 implied] should teach children about the causes, consequences, and potential solutions to global warming, Fig. 1 (Adler 2016, Leiserowitz et al. 2016)."

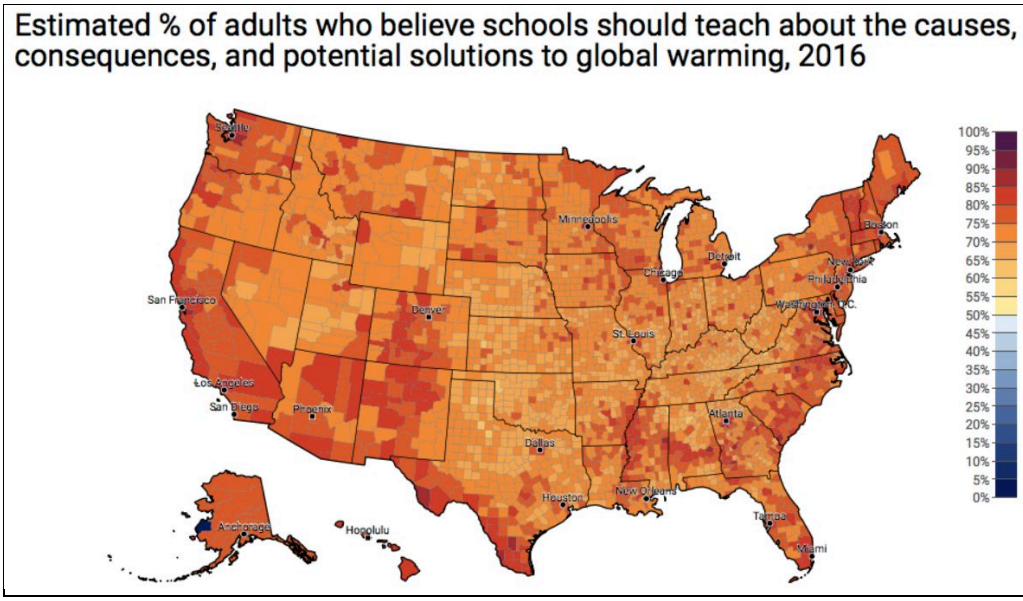


Figure 1 – Per county percentage of surveyed adults (18+) who agree that schools should teach about climate change (Howe et al. 2015)

Fortunately, reflecting on this nationwide support, there has been significant emphasis on K-12 climate change education in the United States for at least the last 15 years (Fretz 2016, Ledley et al. 2017, Mochizuki and Bryan 2015, Shepardson et al. 2011, Shepardson et al. 2017). Since national education standards such as the Next Generation Science Standards (NGSS) do not exist for undergraduate or graduate university programs, there has been no overarching effort to establish robust undergraduate climate change curricula. This is, in part, due to how universities educate students within particular disciplines. While general education is a foundation of undergraduate programs, not every student is required to take every course.

There are suites of courses that satisfy general education requirements at most universities. As such, the onus of educating students about climate change falls to each university individually. In a 2012 article, Cortese noted that universities and colleges serve over 18 million students each year, in addition to wider society, through teaching principles of sustainability and leading by example through campus efforts. Work done by Hess and Collins (2018) showed that the

universities with the greatest penetration of climate change knowledge amongst the student body were those that incorporated climate change curriculum into required courses or had a significant percentage of elective courses within general education requirements that featured significant climate change curriculum.

In 2015, Mochizuki and Bryan presented climate change education principles, for all facets of formal and informal education, in the context of Climate Change Education for Sustainable Development (CCESD) as a facet of the United Nations Educational, Scientific, and Cultural Organization (UNESCO) Climate Change Education plan (initially established in 2012). The article and CCESD emphasize the need for interdisciplinary education that includes addressing preexisting knowledge of climate change, basics of climate change science, social aspects of climate change, equipping students to think critically about societal issues related to climate change, and more. It directly calls out the role that higher education should play in the total education process. The report underscores the need to prepare students for the realities of the world they will face as adults as well as how employment and other life factors can—and will be—affected by climate change (Mochizuki and Bryan 2015).

At the 23rd Conference of the Parties (COP23) to the 1992 United Nations Framework Convention on Climate Change (UNFCCC), there was a call to adhere to the Doha Programme established at COP18 in 2012 (Education: A Powerful Tool for Combatting Climate Change 2017). This call was for all aspects of formal and informal climate change education to be made an international and national priority through new educational policies since preparing future generations for living in a changed environment, changed society, and changed workforce will be critical for their success and the success of the global economy. Toward this end, UNESCO provided a Climate Change Education Statement outlining existing international policies and recommendations on climate change education (UNESCO at COP23: Climate Change Education 2017). While these recommendations have not yet translated into many national policies, educators around the world are supporting a groundswell of climate change education programs. Fortunately, as part of this movement, undergraduate minors are now offered in climate change or climate change-related studies at more than 30 universities both nationally and internationally (ACUPCC 2018, Dyer and Dyer 2017, Filho 2010, Jamelske 2013, Makrakis and Kostoulas-Makrakis 2015, Yoho and Rittmann 2018). These existing programs provide focus for developing additional undergraduate climate change studies at other universities such as the University of California, San Diego.

*Climate Research at University of California San Diego, Scripps Institution of Oceanography*

The University of California, San Diego (UCSD)—home of Scripps Institution of Oceanography (SIO)—employs some of the top climate change researchers and produces some of the most

groundbreaking climate change research in the world (Nature Index 2015). A founder of UCSD, Roger Revelle, began his time with the University as an oceanographer at Scripps with an interest in the carbon cycle and the role of atmospheric carbon dioxide, $CO_2$. In 1957, Revelle along with Hans Suess published an article demonstrating that $CO_2$ in the atmosphere had increased as a result of the burning of fossil fuels. In 1965, while on the President's Science Advisory Committee Panel on Environmental Pollution, Revelle helped bring the issue of the global implications of anthropogenic $CO_2$ emissions to the public through the publication of the first comprehensive government report on the subject. Roger Revelle is variously known as "the father of UC San Diego," "the grandfather of the greenhouse effect," and one of the greatest spokespersons for science in modern times.

Revelle recruited Charles David Keeling to Scripps to support work on atmospheric $CO_2$ that started with the International Geophysical Year. Keeling's work has become perhaps the famous example of SIO climate change research with the most well-known visualization of increasing atmospheric $CO_2$ leading to anthropogenic climate change—The Keeling Curve. The Keeling Curve, a record of continuous atmospheric $CO_2$ measurements, comes from an experiment started by Dave Keeling as post-doctoral work in March 1958 at an observatory on Mauna Loa in Hawaii. Keeling continued his work on $CO_2$ at Scripps until he passed away in 2005, at that time his son Ralph Keeling took over the Scripps $CO_2$ Program which he continues to lead. As of 2018, there are 10 monitoring stations from Alaska to the South Pole that sample atmospheric $CO_2$ as SIO continues to monitor global $CO_2$ levels. In 2015, The Keeling Curve was named a National Historic Chemical Landmark by The American Chemical Society for its contributions to the knowledge of the impact of anthropogenic $CO_2$ on the environment, its connections to climate change, and its international status as "the most widely recognized record of mankind's impact on the earth" (Monroe 2015).

One of the most well-known scientists currently working at Scripps is Veerabhadran "Ram" Ramanathan. In his early career before coming to UCSD, Ramanathan established his credentials as a climate scientist by discovering the greenhouse effect of halocarbons in 1975; in 1980 with Roland Madden, predicting that global warming would be detected by 2000; leading the first international assessment on the effects of greenhouse gases (GHGs, other than $CO_2$) in 1985; helping develop the first version of the community climate model for the U.S. in the 1980s; in 1989, leading a study through NASA using satellite instruments to uncover the global cooling effects of clouds; and in the 1990s, with Paul Crutzen, leading an international experiment discovering the widespread Atmospheric Brown Clouds (ABCs) over Southern Asia. His recent work on short-lived, high-impact GHGs led to the "Kigali Deal" to eliminate the manufacture of hydrofluorocarbons (HFCs), GHGs several thousand times more potent than $CO_2$ with a fraction of $CO_2$ residence time in the atmosphere. As if all this was not enough, Ramanathan provided the inspiration for Pope Francis' encyclical *Laudato Si*, the Pope's 2015

proclamation on the need to act on climate change to the global Catholic church; subsequently, in February 2018, Pope Francis named Ramanathan the Vatican Climate Scientist.

These examples demonstrate how UCSD and SIO stand out leaders in research on climate science and understanding the impacts and challenges climate change poses. UCSD also strives to be a leader in the development of innovative solutions to address climate change challenges through avenues such as the University of California (UC) system-wide commitment to carbon neutrality by 2040 (ACUPCC, 2018) and the strategic initiative, Understanding and Protecting the Planet (UPP), (UC San Diego Strategic Plan, Goal 3, Strategy 6 2014).

*Climate Change and Climate Change Policy in California*

California stands out among other states—even among other countries—as a leader of efforts to understand, educate, and legislate about climate change and climate change impacts to the environment, human society, and the economy. Recently advancing to the world's fifth largest economy, California is successfully decoupling growth from carbon emissions thanks in part to the climate policies it has enacted. Starting in the mid-2000s with Assembly Bill 32 (AB32). The California Global Warming Solutions Act of 2006, most commonly known as AB32, aimed to reduce California's GHG emission to 1990 levels by 2020 with a goal to maintain and continue reductions post-2020. This was the first climate legislation in California and "secured the State's role as a national and global leader in reducing GHGs (California Air Resources Board 2017)."

The election of Governor Jerry Brown in 2014 was the prelude to rapid additional climate legislation in the state. In April 2015, Governor Brown issued Executive Order B-30-15 deepening the commitment of AB32 by calling for an emissions reduction target for California of 40% below 1990 levels by 2030 (known as 40 by 30). Senate Bill 32 (SB32), the California Global Warming Solutions Act of 2016 and Assembly Bill 197 (AB197), are the update to AB32 that put into law Executive Order B-30-15. SB32 codifies the new emissions target of 40 by 30. This new target reflects the science that informed to 2015 Paris Agreement and represents the most ambitious reduction target in North America. AB197 calls for transparency throughout the State with the annual posting of data related to the target guidelines. Perhaps most importantly, AB197 requires consideration of the social cost of carbon and the protection of the most disadvantaged and impacted communities.

Other California state climate policies include:

- Assembly Bill 1504 (AB 1504) directing the Board of Forestry and Fire Protection to adopt forest management rules ensuring that regulations governing harvesting consider the capacity of forest resources to sequester $CO_2$ emissions sufficient to meet or exceed sequestration targets.
- Senate Bill 350 (SB350), Golden State Standards, requiring the State to set reduction targets through Integrated Resource Planning in various electric utilities and providers. SB350 also

establishes increases in the Renewables Portfolio Standard (RPS) to 50% by 2030 and doubled the energy savings requirements for elements of the electricity and natural gas sectors.

- Senate Bill 1383 (SB1383) institutes a strategy regarding short-lived climate pollutants (SLCPs), including the reductions below 2013 levels by 2030 of methane by 40%, HFCs by 40% and anthropogenic black carbon by 50%.
- Senate Bill 1386 (SB1386) declaring it state policy that managing and protecting natural and working lands is a key strategy toward meeting California's GHG reduction goals.
- Assembly Bill 398 (AB 398), California Global Warming Solutions Act of 2006 Statutes of 2017, clarifies the State's Cap-and-Trade Program from January 1, 2021 through December 31, 2030. Among other key features, the bill requires the designation of the Cap-and-Trade Program as the mechanism for reducing emissions oil and natural gas production and refinery facilities.
- Assembly Bill 617 (AB617), a companion bill to AB398, outlines air quality monitoring and reduction of air pollution in locations that can be defined as areas of social and environmental justice concern. Monitoring systems, evaluation plans, and an annual reporting system must be in place and operational by July 1, 2019 with a plan to evaluate and deploy new systems on an annual basis (California Air Resources Board 2017).

*Climate Change Education at University of California San Diego*

While UCSD offers several climate change-related courses (UC San Diego General Catalog 2017-18), before 2018 the University had no identified undergraduate curriculum in climate change and no metrics in place to assess how much knowledge students typically acquire about climate change during their time on campus. In early 2016, in an effort to expand climate change education at UCSD, 24 faculty from 21 departments participated in a curriculum development workshop where they developed plans to infuse aspects of climate change into existing undergraduate courses. This successful program produced over 20 courses with embedded climate change curriculum that were offered during the 2016-2017 academic year. These courses (with enrollments of over 3,800 students) included Genetics, Organic Chemistry, college writing courses, Introduction to Theatre, Nanoengineering, and Ethics and Society. This pilot provided proof of concept that embedded climate change curriculum would have a broad reach amongst undergraduate students.

In 2017, a proposal was submitted through the UPP initiative to secure funding to further advance climate change education at the University. The proposal consisted of three initiatives: 1) a survey of undergraduate students at UCSD to assess their understanding and attitudes on climate change, 2) a second workshop to infuse climate change education across disciplines by leveraging faculty expertise, and 3) the establishment of a climate change curriculum task force to create an interdisciplinary, undergraduate degree program in climate change studies at UCSD. Undergraduate students were surveyed in the Fall 2017 and Winter 2018 quarters. Results from this survey were used to inform curriculum needs for a degree program, and the second workshop was offered in Spring 2018 to faculty in curricular areas that needed additional climate change content.

This report focuses on the creation of the interdisciplinary, undergraduate Climate Change Studies Minor (CCSM). The CCSM was designed to enhance the visibility of UCSD's existing course content and campus initiatives around climate in a curriculum open to any student from any major. Focusing on the three key areas of climate change discourse—science, human and social dimensions, and solutions—the CCSM curriculum was further informed by climate change education research (Aksit et al. 2017, Bhaskar 2010, Filho 2010, Fretz 2016, Hess and Collins 2018, Jamelske et al. 2013, Ledley et al. 2017, Leiserowitz 2011, Makrakis and Kostoulas-Makrakis 2015, Mochizuki and Bryan 2015, Moser 2010, Moser and Dilling 2011, Pearce and Russill 2005, Pharo et al. 2012, Shepardson et al. 2011, Shepardson et al. 2017, Yoho and Rittmann 2018) and was developed as an examination of climate change across disciplines. Establishing this recognizable curriculum in climate change studies at UCSD aligned with the University's academic strengths and the strategic initiative to "develop students who are capable of solving problems, leading, and innovating in a diverse and interconnected world (UC San Diego Strategic Plan, Goal 1)."

## Development Process

*Undergraduate Freshman Understanding of Climate Change Survey*

In December 2017 and January 2018, undergraduate intern Kol Chaiken administered the Undergraduate Freshman Understanding of Climate Change (UFUCC) survey to over 1,500 UCSD undergraduate students. This survey yielded 796 complete data sets across a series of questions on students' climate change beliefs and knowledge. Results from this survey were used to identify gaps in students' climate change knowledge. This information assisted the task force advisory committee toward the supplementation of existing courses and the creation of new courses as necessary to fill curricular gaps.

Questions for the UFUCC survey came from two previous survey projects (Howe et al. 2015, Leiserowitz et al. 2011). Howe et al. (2015) was the primary basis for the UFUCC survey and all questions from the Howe et al. analysis were used in the UFUCC survey. The questions used by Howe et al. originated from the seminal paper, "Global warming's six Americas 2009: An audience segmentation analysis" (Maibach et al 2009). Additional questions in the UFUCC survey were from "American teens' knowledge of climate change" (Leiserowitz et al. 2011). Eleven additional questions were formulated by the survey team; three questions were modeled after the Leiserowitz et al. (2011) study questions on survey participant thoughts on actions to reduce global warming, two questions related to knowledge of the UC Carbon Neutrality Initiative, and six questions were for analytical purposes related to student demographics. The questions from this survey are provided in Supplementary Materials, S1.

*Feasibility Study for Climate Change Studies Degree at University of California San Diego*

Climate Change Education Research

In order to implement an effective climate change curriculum, an understanding of the field of climate change education was needed. To this end, a review was undertaken of research on existing climate change studies minor programs, climate change communication, climate change education, climate science, science communication, interdisciplinary education, and the climate change beliefs and knowledge of university students (Aksit et al. 2017, Bhaskar 2010, Filho 2010, Fretz 2016, Hess and Collins 2018, Jamelske et al. 2013, Ledley et al. 2017, Leiserowitz 2011, Makrakis and Kostoulas-Makrakis 2015, Mochizuki and Bryan 2015, Moser 2010, Moser and Dilling 2011, Pearce and Russill 2005, Pharo et al. 2012, Shepardson et al. 2011, Shepardson et al. 2017, Yoho and Rittmann 2018).

Advisory Committee

Using information from the UFUCC survey, the advisory committee identified courses that could assist in filling gaps in student knowledge about climate change and make relevant aspects of climate change science, human and social dimensions, and solutions more apparent to students across various fields of study. Since climate change will in some way impact essentially every job in every sector in the future, the advisory committee decided that pursuing a climate change studies curriculum for a minor degree that could be coupled with any major degree was most appropriate.

Faculty Committee

The courses identified by the advisory committee were placed in a degree structure to emphasize the interdisciplinary nature of climate change issues. Structured sections focus on solutions to climate change causes and impacts, climate science, the human and social dimensions of climate change, and practical application of knowledge gained in these areas. The advisory committee sought feedback on the minor curriculum from a second committee comprised of representatives including faculty teaching various courses to be included in the minor, a university dean, the director of the Center for Climate Change Impacts and Adaptation, and the director of Campus Sustainability and Carbon Neutrality. Advice from this committee was used to modify the degree structure and incorporate additional courses into the curriculum.

Course Approvals and Proposal Submission

The departments of the chosen courses were contacted by the advisory committee to seek approval for inclusion in the proposed minor curriculum. Departments responded by 1) giving permission to include the requested courses, 2) removing a requested course that was no

longer offered and submitting new course(s) to replace it, 3) removing a course that was restricted to majors within the department because of enrollment issues and submitting new course(s) to replace it or approving other course(s) that were also requested. Only one department removed a requested course because it was no longer offered and had no course to offer in its place. All other departments approved courses or submitted new course(s) to replace ones they could not approve. Approving departments submitted a letter of support for the inclusion of the courses. The advisory committee compiled all letters of departmental support, completed the formal proposal for the Climate Change Studies Minor curriculum, and submitted it to the Academic Senate Undergraduate Advisory Council for review in May 2018.

## Results

*Undergraduate Freshman Understanding of Climate Change Survey*

Survey data suggest that, the while majority of incoming undergraduate students at UCSD accept the anthropogenic causes of climate change being currently observed, many students lack a clear understanding of the mechanisms, impacts, and solutions. Belief in anthropogenic climate change of the incoming undergraduate students at UCSD is far greater than the national average, Fig 2. Since 83% of survey respondents went to high school in California, strong emphasis is placed on climate change education in California schools, and some of the compiled adult comparison data is several years old, this result may be somewhat expected. Data from the UFUCC survey also indicates knowledge of *some* of the basic principles of climate science is also greater than data recorded from national surveys of American teen and adult knowledge of climate change, Fig. 3 (Leiserowitz et al. 2010, Leiserowitz et al. 2011). However, somewhat disconcertingly, the misconceptions about climate science found in the same national surveys of American teens and adults are also present among UCSD undergraduates, Fig. 4.

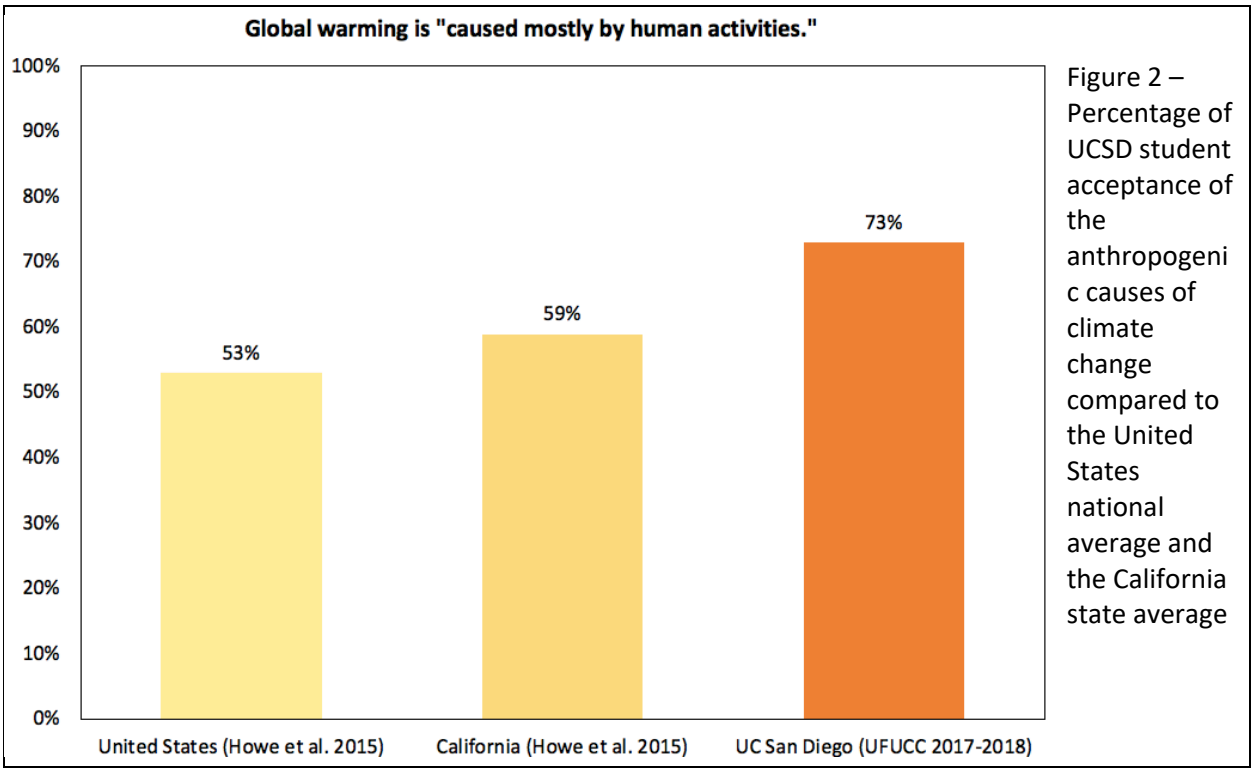


Figure 2 – Percentage of UCSD student acceptance of the anthropogenic causes of climate change compared to the United States national average and the California state average

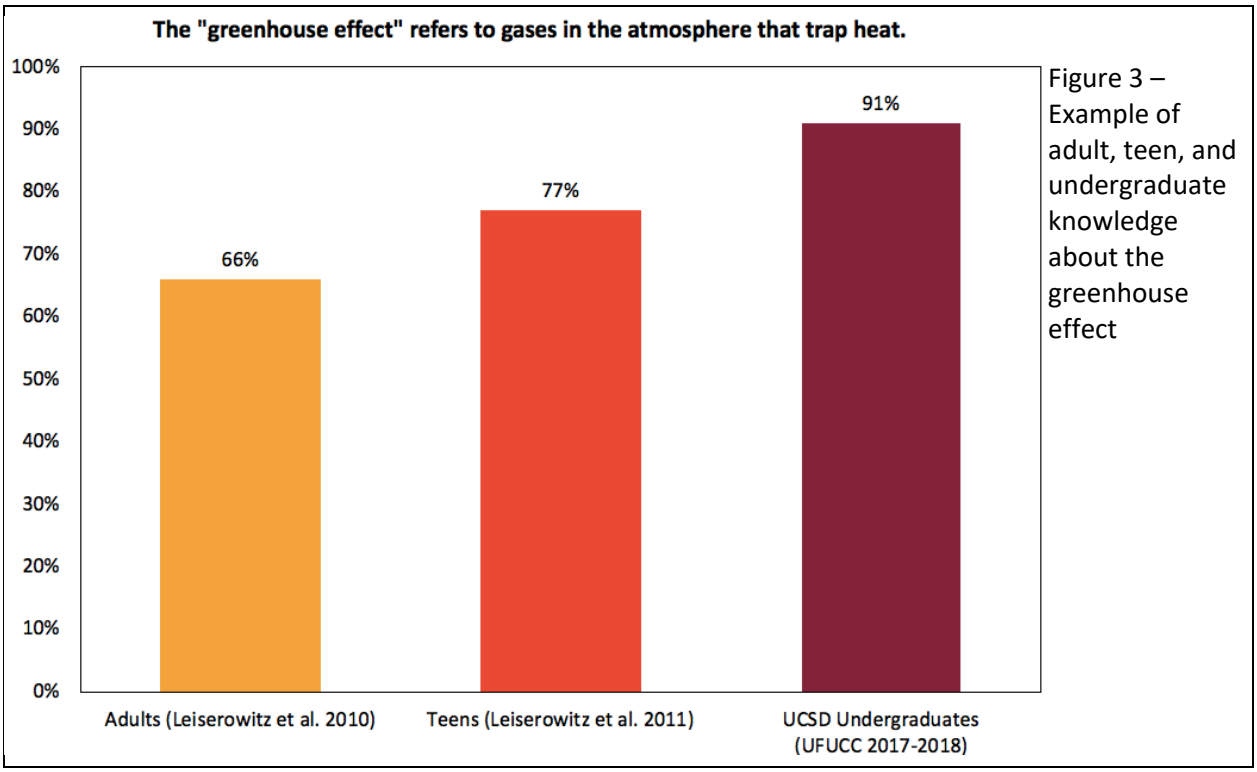


Figure 3 – Example of adult, teen, and undergraduate knowledge about the greenhouse effect

The findings of these national surveys and the UFUCC survey stem from years of well-intentioned but bungled climate change communication (Moser 2010, Moser and Dilling 2011). Historically, climate change communication in formal education (K-graduate) has most often

been employed in a narrow range of formats by teachers, professors, and scientists that did not have a thorough understanding of appropriate science communication techniques or social science research on science communication (Moser 2010, Moser and Dilling 2011, Shome and Marx 2009, Sterman 2011). Recent literature indicates audience-focused, issue-specific, and framed messages are the most effective means of communication and education for behavior change and public action on climate change policy (Center for Research on Environmental Decisions 2009, Moser 2010, Moser and Dilling 2011, Sterman 2011, Weber and Stern 2011).

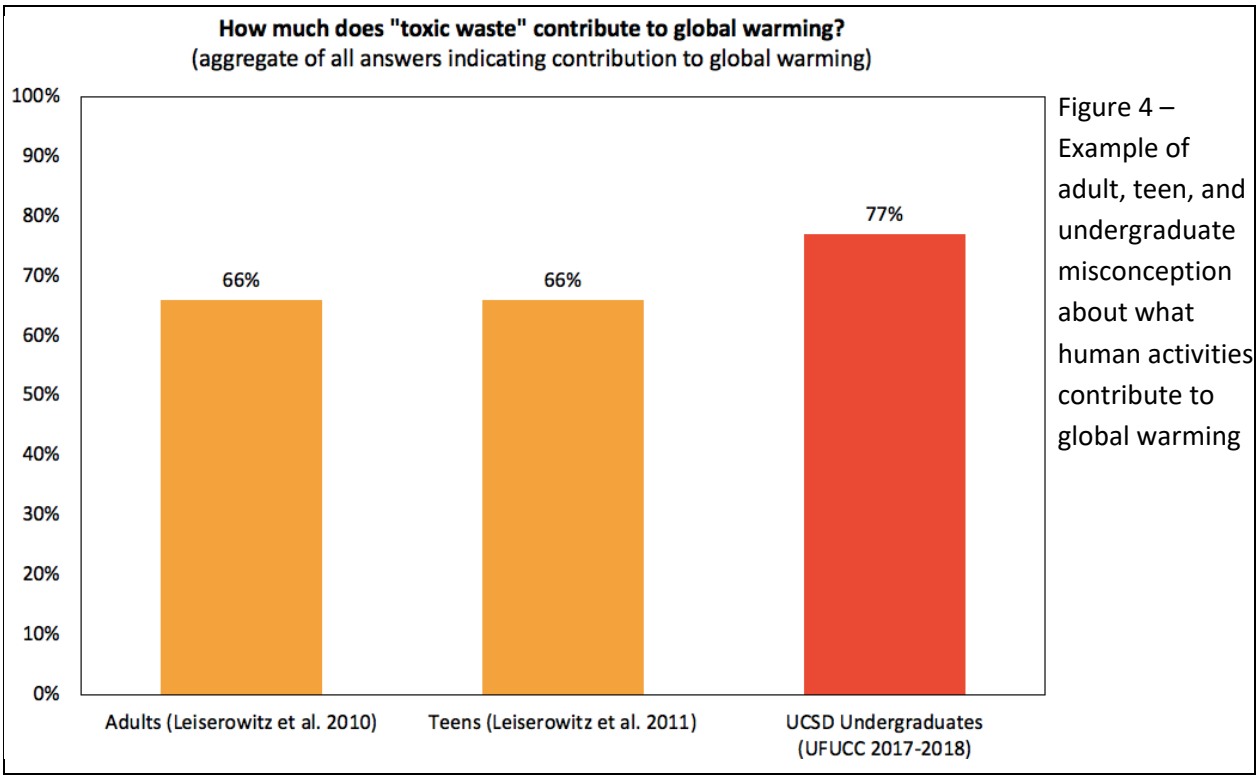


Figure 4 – Example of adult, teen, and undergraduate misconception about what human activities contribute to global warming

*Development of Climate Change Studies Minor at University of California San Diego*

Committee Review

From the UFUCC survey, it was evident that many basics of climate science were unknown or unclear to incoming freshman students at UCSD. The advisory committee identified courses in climate science as critical to fill these knowledge gaps, Fig. 4. It was also apparent that many of the human and social dimensions of climate change, as well as the potential solutions to climate change concerns, were unfamiliar or misunderstood. An example of such a misunderstanding of the human connection to climate change is revealed through students' responses to the question, "How much do you think global warming will negatively impact…you personally; people in the United States; people in developing countries; future generations of people; plant and animal species?" The majority of students (88%) thought that plant and

animal species would be negatively impacted a great deal, while people in the United States (41%) and they themselves (45%) would only be negatively impacted a moderate amount. Indeed, if plants and animals are impacted a great deal, humans will be impacted a great deal as well through the loss of ecosystem services provided by the natural world. The disparity between the perceived impact on plants and animals (ecosystem services) and on themselves and their countrymen demonstrates an information gap.

Survey data shed light on what students needed to learn, and with advice from the faculty committee, the advisory committee designed an interdisciplinary degree structure focused on climate science, the human and social dimensions of climate change, solutions to climate change causes and impacts, and practical application of climate change knowledge. The Climate Change Studies Minor (CCSM) was created using 54 existing courses ranging across 12 departments (UC San Diego Course Catalog) with four proposed Climate Change Studies (CCS) courses to be created for the *Climate Change: Practicum* section. The degree structure is provided in Supplementary Material, S2.

### Climate Change Education Research

Reviewing the research on existing minor programs, communication, education, science, education, and beliefs and knowledge of university students, revealed the need for an interdisciplinary curriculum in climate change studies emphasizing solutions and real-world applications.

## Discussion

### *Undergraduate Freshman Understanding of Climate Change Survey*

Since incoming undergraduate students at UCSD accept the observed anthropogenic causes of climate change and generally support policy to mitigate $CO_2$ emissions and adapt to climate change impacts, it appears the primary educational need centers around students' personal connection to the causes, consequences, and solutions to climate issues. Research on the range of what the public does and does not know about climate change, as well as the belief systems that may influence behavior regardless of knowledge, resulted in the suggestions to increase education regarding adjustments to mental models around climate change and to include more communication informed by psychological research (Weber and Stern 2011).

Humans use mental models to grasp complex phenomena; however, in efforts to understand new and unfamiliar circumstances, the use of preexisting mental models can lead to misconceptions and confusion about how to properly respond to novel situations (Ledley et al. 2017, Sterman 2011, Weber and Stern 2011). A problematic mental model that has often been applied to emissions leading to climate change is the concept of "pollution." The idea that "the

air will clear" or that "the solution to pollution is dilution" leads many to believe that global warming will end shortly after emissions are reduced (Weber and Stern 2011). A better mental model for global warming would be that of "stocks and flows" or "filling and draining a bathtub." Yet, research shows that preexisting mental models cannot simply be replaced, misconceptions must first be addressed, and explanations given for why a preexisting mental model does not match new circumstances (Linden et al. 2017, National Resource Council 2004). Only then can new mental models be introduced that accurately reflect the scientific reality of the new situation.

In the same vein of addressing inaccurate mental models and misconceptions, higher education institutions are also an avenue of power to counter myth with truth (Hess and Collins 2018), and a time devoted to identifying students' preconceptions and actively "myth-busting" could prove to be crucial to the success of climate change education programs (Linden et al. 2017, Ledley et al. 2017, Weber and Stern 2011). Ledley et al. (2017) observe that "[c]orrecting fundamental misconceptions…must clearly be one goal of climate change education, communication, and decision support, especially as causal thinking about climate change has been linked to support for policies to address it."

*Development of Climate Change Studies Minor at University of California San Diego*

Data from the survey of UCSD undergraduates and insights from climate change education research guided the development of the curriculum for the CCSM. The driving evidence from the survey of UCSD students were the issues of 1) information gaps, 2) misconceptions, and 3) lack of personal connections between students and the impacts of climate change and climate change solutions.

Supplementary anecdotal reports from UCSD undergraduates indicate a lack of knowledge across intended majors about climate change course offerings and that many students are looking for climate change courses relevant to their major field of study. Several case studies support these reports, suggesting that an undergraduate climate change program should be interdisciplinary in nature to have the greatest chance at reaching a diversity of students and ensuring the success of those students in the future (Aksit et al. 2017, Bhaskar 2010, Campbell 2016, Filho 2010, Fretz 2016, Pearce 2005, Pharo et al 2012, Shepardson et al. 2017). One case study (Filho 2010) reviewed a climate change education survey of 1,250 university students from 166 universities in 43 countries. Students were questioned about their knowledge of and desires around university education on climate change. Important observations from the students' perspective included: lack of climate change courses on the human dimensions of climate change, climate change as a topic was not as well-covered as

students expected or desired at their universities, and students articulated desire for more emphasis on climate change in various university courses (Filho 2010).

Another important observation comes from an external review of the first Climate Change Studies program established in the United States at the University of Montana, Missoula in 2009. In a 2016 letter to the university provosts, the reviewer made two affirming observations and several other recommendations regarding the program (Campbell 2016). The first affirmation was that the focus of the program is appropriately broad as compared with other climate change minor programs. The reviewer noted that at some universities minor programs were too narrowly focused, looking at only one aspect of climate issues (e.g. science or energy but not both or more). Other universities were too broad, dealing with sustainability in general without any topic focus. The second affirmation regarded the emphasis on giving the students practical experience through fieldwork and experimentation. The reviewer spent additional time praising and emphasizing the multidisciplinary nature of the program and recommended expanding the program further to include other disciplines at the university.

Many other case studies give evidence of the need for university programs on climate change studies to be interdisciplinary in nature. These include the observations of Pearce et al. (2005) on a cross-disciplinary project between a communications course and a general science; the case study at three campuses of University of Tasmania in 2012 (Pharo et al.) that showed the critical role of the "network facilitator" in providing connectivity between the various university programs and departments; the work being done to build by the international CLIMAte change and Sustainability Policy (CLIMASP) program to build interdisciplinary climate change studies minors across 10 universities in the Middle East–North Africa region (Makrakis and Kostoulas-Makrakis 2015); and the review by Aksit et al. (2017) of climate knowledge and risk perception that found that infusing climate change into lecture-based courses provides significant learning gains even if climate change is not the focus of a course.

Working from the survey data and the climate change education research that demonstrated overwhelming need for climate change study programs to be interdisciplinary in nature, a degree structure was designed by the advisory committee. Minors at UCSD must consist of twenty-eight units of coursework. These units were distributed across four focus areas: Solutions, Science, Human and Social Dimensions, and a Practicum. To meet the minor requirements, students must take one four-unit solutions course, two four-unit science courses, two four-unit social and human dimensions courses, and three (or more) practicum courses for a total of eight units.

*Climate Change: Solutions* is the first focus area of the minor to raise the profile of solutions to climate change issues and impacts for the undergraduates interested in the minor. Countless

research articles on climate change communication and education in the last decade have made clear the need to move toward positive messaging about climate change that centers on solutions and hope for change in the future (Expanding Our Repertoire: Why and How to Get Collective Climate Change Solutions in the Frame 2017, Moser 2010, Moser and Dilling 2011, Shome and Marx 2009). Unfortunately, the mass media have not followed this advice and too much fear and negativity about climate change is conveyed to the public daily. Since several studies observe that undergraduate years are a critical learning juncture for many students preparing to enter the workforce (Aksit et al. 2017, Bhaskar 2010, Filho 2010, Hess and Collins 2018, Pearce and Russill 2005, Pharo et al. 2012), the advisory committee chose to frame the minor is a positive, solutions-focused light by starting the minor structure with an emphasis on solutions. Additionally, with the knowledge of the crucial role that diverse perspectives play in the climate solutions landscape, the design of minor curriculum implements learning practices that have been linked to increased recruitment and success of minority students, including early exposure to applications in the discipline, research and internship opportunities, coursework that emphasizes altruistic values, strong mentoring, and individualized advising (Bernard and Cooperdock 2018, Gilligan and Ebanks 2016, Johnson et al. 2016).

*Climate Change: Science* is the second focus area to ensure students have a solid foundation in the science behind the issues and impacts to clearly define the mechanisms of climate change processes and correct any student misconceptions. There is a course requirement in this section that focuses specifically on climate change science to fill in the information gaps and correct any misconceptions, as identified in the UFUCC survey. The additional unit requirement in this section is an elective so students can ideally match any requirements for their majors. This was thoughtfully implemented as a means to interest students in this minor because some students are attracted to minors based on how many courses overlap between major and minor requirements. This section is also where the majority of SIO courses can be found. It is the hope of the advisory committee that students will spend more time engaging with SIO through these courses and, as a result, be motivated to pursue an internship or independent study with one of the scientists or research labs as part of the practicum requirement.

*Climate Change: Human and Social Dimensions* is the third focus area to connect students to the aspects of climate change issues and impacts (now and in the future) that directly affect or are affected by their own actions and indirectly affect them through societal or environmental consequences. At the moment, there is no course requirement in this section, but it is here that we have identified two of the greatest holes in the curriculum. The faculty committee brought attention to the lack of any course covering indigenous perspectives of climate change. Since indigenous knowledge of the deep history of local climate is invaluable to the work of scientists studying climate change, a new course is being designed to connect students to the complexity and importance of indigenous connections to climate and how it is changing.

Most concerning to the advisory committee was the complete lack of any climate change policy course available to undergraduates at the University. There are a few courses at the graduate level, but there is a difficult petition process and the majority of the time undergraduates are not accepted. On the advice of the advisory committee, a new course is being developed to cover various aspects of climate change and environmental policy based largely on the policies developed by the state of California. Once the curriculum has been written and these courses are approved, these will become part of the requirement for this area of the degree.

*Climate Change: Practicum* is the fourth focus area, created specifically to fill the final curriculum gaps and an intended hallmark of the climate change studies minor. The research on climate change education indicated a need for hands-on experience with solutions and practical applications of the knowledge students gain about climate change issues and impacts. The advisory committee also felt it was critical to give the students the opportunity to work interdisciplinarily with the minor cohort. Hence, this section is made up of four proposed courses with a new designation, Climate Change Studies (CCS), that will be specific to this degree program.

The *Carbon Neutrality Initiative at University of California* (CCS 101) course introduces the UC system-wide goals of the Carbon Neutrality Initiative through a series of modules where students learn basic principles of carbon neutrality, participate in seminars with campus operations staff, and tour relevant campus infrastructure including the UCSD microgrid, LEED-certified buildings, and sustainable transportation efforts. The *Research Perspectives on Climate Change* (CCS 102) course introduces students to exciting and current research topics related to climate change as presented by faculty and researchers across UC San Diego. The course is offered as a series reading topics followed by seminars on original research presented by faculty and researchers. The *Carbon Neutrality Internship* (CCS 190) is a campus-based internship, typically designed by the student, which will help the university meet our stated Carbon Neutrality goals. The project can be developed either individually or as part of a team. A written contract involving all parties will include learning objectives, a paper/project outline, and means of supervision and progress evaluation. The *Supervised Independent Study or Research* (CCS 199) is independent reading or research on a topic related to climate change by special arrangement with a faculty member. The CCS 101 and CCS 102 course will be required for all degree participants, and one or both CCS 190 and CCS 199 will also be required for degree completion.

These four degree sections are comprised of 54 existing courses ranging across 12 departments: Biology, Political Science, Mechanical Engineering, Anthropology, Chemistry, Sociology, Environmental Systems, Psychology, Environmental Studies, Business Management, Urban Studies and Planning, Philosophy, Economics, Ethnic Studies, History, Communications,

and Scripps Institution of Oceanography (UC San Diego Course Catalog). Only four new courses were proposed for the *Climate Change: Practicum* section.

*Recommendations for Replication at Other Universities*

The keys for the creation of this minor proposal were:

1) Emphasis on interdisciplinary structure and courses,
2) Emphasis on climate change solutions,
3) Emphasis on hands-on, practical applications, and
4) Use of existing courses with a small number of proposed courses.

UCSD had a wealth of existing courses that covered many of the aspects of climate change education that were shown in the literature to be critical to student knowledge gains and success in student engagement in the topic. The advisory committee was a small team that leveraged the resources of an intern, a graduate student, and a faculty committee along with existing courses from the University to create a proposal for a new minor degree in Climate Change Studies in under nine months. Additional courses to fill some of the curriculum gaps are under development, and a further consideration for this curriculum is informed by the Hess and Collins (2018) study.

This study reveals that students may self-select out of courses focused on climate change or that have a substantial portion of climate change covered in their syllabi. To circumvent this, the authors suggest including climate change in the core curriculum requirements of American universities. The universities that showed the highest probability of students completing at least one climate-change related course offered climate change courses as part of their core education requirements (Hess and Collins 2018). A workshop was recently given (and more are being considered) to demonstrate to faculty how climate change can be infused to existing courses at UCSD.

## Conclusion

The proposal developed for the Climate Change Studies Minor was presented to the UCSD Academic Senate Undergraduate Council on May 11, 2018. On June 8, 2018, the Council voted to accept the proposal and the minor should become available for undergraduate student enrollment in Winter 2019.

## Acknowledgments

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## References

ACUPCC, 2018. American College & University Presidents' Climate Commitment. (n.d.) Retrieved February 24, 2018, from http://www.acupcc.org/.

Adler, S. (2016, August 23). School's starting: A majority of Americans say global warming should be taught in the classroom. [Web log post]. Retrieved March 20, 2018, from http://climatecommunication.yale.edu/news-events/schools-starting-majority-americans-say-global-warming-taught-classroom/

Aksit, O., McNeal, K. S., Gold, A. U., Libarkin, J. C., & Harris, S. (2017). The influence of instruction, prior knowledge, and values on climate change risk perception among undergraduates. *Journal of Research in Science Teaching*.

Bernard, R.E. and Cooperdock, E.H.G. (2018). No progress on diversity in 40 years. *Nature Geoscience* 11: 292-295.

Bhaskar, R. (Ed.). (2010). *Interdisciplinarity and climate change: Transforming knowledge and practice for our global future*. Taylor & Francis.

California Air Resources Board. (2017). *California's 2017 Climate Change Scoping Plan*. Sacramento, CA.

Campbell, S. (2016, April 6). External Review of Climate Studies Program [Letter to Provost Perry Brown and Associate Provost Nathan Lindsay]. University of Montana, Missoula, Montana.

Cortese, A. D. (2012). Promises made and promises lost: A candid assessment of higher education leadership and the sustainability agenda. *The sustainable university: Green goals and new challenges for higher education leaders*, 17-31.

Dunlap, R. and McCright, A., 2015. Challenging climate change: the denial counter movement. In: Dunlap, R., Brulle, R. (eds.), *Climate Change and Society: Sociological Perspectives*. Oxford University Press, New York, NY, pp. 300-332.

Dyer, G., & Dyer, M. (2017). Strategic leadership for sustainability by higher education: the American College & University Presidents' Climate Commitment. *Journal of Cleaner Production*, *140*, 111-116.

Education: A Powerful Tool for Combatting Climate Change [Pamphlet]. (2017). Brussels, Belgium: Education International.

*Expanding Our Repertoire: Why and How to Get Collective Climate Solutions in the Frame* (Rep.). (2017). Washington, DC: FrameWorks Institute.

Filho W.L. (2010) Climate Change at Universities: Results of a World Survey. In: Leal Filho W. (Eds.) *Universities and Climate Change. Climate Change Management*. Springer, Berlin, Heidelberg. doi: 10.1007/978-3-642-10751-1_1.

Fretz, E. J. (2016). *Climate change across the curriculum*. Lanham: Lexington Books.

Gilligan, M., & Ebanks, S. (2016). The Ocean Science Social Diversity Challenge. *Oceanography*, 29 (1), 55-57.

Hess, D. J., & Collins, B. M. (2018). Climate change and higher education: Assessing factors that affect curriculum requirements. *Journal of Cleaner Production*, 170, 1451-1458.

Howe, P., Mildenberger, M., Marlon, J., & Leiserowitz, A. (2015). "Geographic variation in opinions on climate change at state and local scales in the USA," *Nature Climate Change*. DOI: 10.1038/nclimate2583.

IPCC, 2014: Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, Pachauri, R.K. and Meyer, L.A. (Eds.)]. IPCC, Geneva, Switzerland, 151 pp.

Jamelske, E., Barrett, J., & Boulter, J. (2013). Comparing climate change awareness, perceptions, and beliefs of college students in the United States and China. Journal of Environmental Studies and Sciences, 3(3), 269-278.

Johnson, A., Huggans, M.J., Siegfried, D., and Braxton, L. (2016). Strategies for increasing diversity in the ocean science workforce through mentoring. *Oceanography* 29 (1):46–54.

Ledley, T. S., Rooney-Varga, J., & Niepold, F. (2017*). Addressing Climate Change Through Education*. Oxford Research Encyclopedia of Environmental Science. doi:10.1093/acrefore/9780199389414.013.56.

Leiserowitz, A., Smith, N. & Marlon, J.R. (2010). *Americans' Knowledge of Climate Change*. Yale University. New Haven, CT: Yale Project on Climate Change Communication.

Leiserowitz, A., Smith, N., & Marlon, J. R. (2011). *American teens' knowledge of climate change*. Yale University. New Haven, CT: Yale Project on Climate Change Communication, 5.

Leiserowitz, A., Maibach, E., Roser-Renouf, C., Feinberg, G., & Rosenthal, S. (2016). *Climate change in the American mind: March, 2016*. Yale University and George Mason University. New Haven, CT: Yale Program on Climate Change Communication.

Leiserowitz, A., Maibach, E., Roser-Renouf, C., Rosenthal, S., Cutler, M., & Kotcher, J. (2018). *Climate change in the American mind: March 2018*. Yale University and George Mason University. New Haven, CT: Yale Program on Climate Change Communication.

Van der Linden, S., Leiserowitz, A., Rosenthal, S., & Maibach, E. (2017). Inoculating the public against misinformation about climate change. *Global Challenges*, 1(2).

Maibach, E., Roser-Renouf, C., & Leiserowitz, A. (2009). *Global warming's six Americas 2009: An audience segmentation analysis*. Yale University and George Mason University. New Haven, CT: Yale Program on Climate Change Communication.

Makrakis, V., & Kostoulas-Makrakis, N. (2015). A strategic framework for developing interdisciplinary minors on climate change and sustainability policy: The CLIMASP-Tempus example. In *Integrating sustainability thinking in science and engineering curricula* (pp. 103-115). Springer, Cham.

Mochizuki, Y., & Bryan, A. (2015). Climate change education in the context of education for sustainable development: Rationale and principles. *Journal of Education for Sustainable Development*, *9*(1), 4-26.

Monroe, R. (2015, June 02). *American Chemical Society to Honor Keeling Curve in June 12 Ceremony*. Retrieved

March 16, 2018, from https://scripps.ucsd.edu/programs/keelingcurve/2015/06/02/american-chemical-society-to-recognize-keeling-curve/#more-1297

Moser, S. C. (2010). Communicating climate change: history, challenges, process, and future directions. *Wiley Interdisciplinary Reviews: Climate Change*, *1*(1), 31-53.

Moser, S. C., & Dilling, L. (2011). Communicating Climate Change: Closing the Science- Action Gap. In *The Oxford Handbook of Climate Change and Society.* Oxford University Press. doi:10.1093/oxfordhb/9780199566600.003.0011.

National Research Council. (2004). *How students learn: History, mathematics, and science in the classroom.* National Academies Press.

Nature Index. (2015). Retrieved March 20, 2018, from https://www.natureindex.com/annual-tables/2014/institution/academic/earth-and-environmental/countries-United States of America (USA)

Pearce, J. M., & Russill, C. (2005). Interdisciplinary environmental education: communicating and applying energy efficiency for sustainability. *Applied Environmental Education & Communication*, *4*(1), 65-72. doi: 10.1080/15330150590911412.

Pharo, E. J., Davison, A., Warr, K., Nursey-Bray, M., Beswick, K., Wapstra, E., & Jones, C. (2012). Can teacher collaboration overcome barriers to interdisciplinary learning in a disciplinary university? A case study using climate change. *Teaching in Higher Education*, *17*(5), 497-507. doi: 10.1080/13562517.2012.658560.

Shepardson, D. P., Niyogi, D., Choi, S., & Charusombat, U. (2011). Students' conceptions about the greenhouse effect, global warming, and climate change. *Climatic Change*, 104(3-4), 481-507.

Shepardson, D. P., Roychoudhury, A., & Hirsch, A. S. (Eds.). (2017). *Teaching and Learning about Climate Change: A Framework for Educators*. Taylor & Francis.

Shome, D., & Marx, S. (2009). *The psychology of climate change communication.* Center for Research on Environmental Decisions, Columbia University, New York.

Sterman, J. D. (2011). Communicating climate change risks in a skeptical world. *Climatic Change*, 108(4), 811.

Van der Linden, S., Leiserowitz, A., Rosenthal, S., & Maibach, E. (2017). Inoculating the public against misinformation about climate change. *Global Challenges*, 1(2).

Weber, E. U., & Stern, P. C. (2011). Public understanding of climate change in the United States. *American Psychologist*, 66(4), 315.

UC San Diego General Catalog 2017–18. (n.d.). Retrieved February 13, 2018, from http://www.ucsd.edu/catalog/.

UC San Diego Strategic Plan, Goal 1. (2014). Retrieved May 29, 2018 from https://plan.ucsd.edu/report/goal-1.

UC San Diego Strategic Plan, Goal 3, Strategy 6. (2014). Retrieved May 29, 2018 from https://plan.ucsd.edu/report/goal-3#strategy6.

UNESCO at COP23: Climate Change Education. (2017). Retrieved March 20, 2018, from http://unesdoc.unesco.org/images/0026/002600/260083e.pdf.

Yoho, R. A., & Rittmann, B. E. (2018). Climate Change and Energy Technologies in Undergraduate Introductory Science Textbooks. *Environmental Communication*, 1-13.

**Supplementary Material, S1 – Undergraduate Survey Questions**

Global warming refers to the idea that the world's average temperature has been increasing over the past 150 years and is likely to continue to increase in the future. Do you agree with this statement?

- Yes
- No
- Don't know

Assuming global warming is happening, do you think it is…?

- Caused mostly by human activities
- Caused mostly by natural variations in the environment
- Approximately equal combination of human activity and natural variation
- None of the above because global warming isn't happening
- Don't know

Which comes closest to your own view?

- An overwhelming majority of scientists think global warming is happening
- The scientific community is approximately equally divided between scientists who think global warming is happening and scientists who think global warming is not happening
- An overwhelming majority of scientists think global warming is not happening
- Don't know enough to say

How much do you trust or distrust climate scientists as a source of information about global warming?

- Strongly trust
- Somewhat trust
- Neither trust nor distrust
- Somewhat distrust
- Strongly distrust

How worried are you about global warming?

- Very worried
- Somewhat worried
- Not very worried
- Not at all worried

When do you think global warming will start to negatively impact people in the United States?

- They are being harmed right now
- Sometime during my lifetime
- Sometime during the next generation's lifetime
- More than 100 years from now
- Never

When do you think global warming will start to negatively impact people in developing countries? [A developing country can be defined as a nation in which important factors of human development, such as life expectancy, per capita income and industrial base are low relative to other countries.]

- They are being harmed right now
- Sometime during my lifetime
- Sometime during the next generation's lifetime
- More than 100 years from now
- Never

How much do you think global warming will negatively impact…? (*Not at all, only a little, a moderate amount, a great deal, don't know*)

- …you personally
- …people in the United States
- …people in developing countries
- …future generations of people
- …plant and animal species

How much do you support or oppose the following policies? (*Strongly support, somewhat support, somewhat oppose, strongly oppose, don't know*)

- Fund more research into renewable energy sources, such as solar and wind power
- Regulate emissions of carbon dioxide (the primary heat-trapping gas) as a pollutant
- Set strict carbon dioxide emission limits on existing coal-fired power plants to reduce global warming and improve public health. Power plants would have to reduce their emissions and/or invest in renewable energy and energy efficiency. The cost of electricity to consumers and companies would likely increase.
- Require electric utilities to produce at least 20% of their electricity from wind, solar, or other renewable energy sources, even if it costs the average household an extra $100 a year

How often do you discuss global warming with your friends and family?

- Often
- Occasionally
- Rarely
- Never

How often do you hear about global warming in the media?

- At least once a week
- At least once a month
- Several times a year
- Once a year or less often
- Never

Are the following statements definitely true, probably true, probably false, definitely false, don't know?

- Weather often changes from year to year
- Climate means the average weather conditions in a region over time
- Climate often changes from year to year
- Climate and weather mean pretty much the same thing

Have you ever heard of the "greenhouse effect"? (*Yes or no*)

The "greenhouse effect" refers to:

- Gases in the atmosphere that trap heat
- The Earth's protective ozone layer
- Pollution that causes acid rain
- How plants grow
- Don't know

How much does each of the following contribute to global warming? (*A lot, some, a little, not at all, don't know*)

- Cars and trucks
- Burning fossil fuels for heat and electricity
- Toxic waste
- Deforestation
- The hole in the ozone layer
- The sun
- Volcanic Eruptions
- Acid rain
- Cows
- The Space Program

How much do you think each of the following actions would reduce global warming if they were done worldwide? (*A lot, some, a little, not at all, don't know*)

- Setting a global goal of 50% renewable energy use by 2050
- Putting a large tax on all carbon dioxide emissions
- Setting a cap on allowable carbon dioxide emissions.
- Stop eating beef
- Using airplanes to scatter particles high in the atmosphere

Have you heard of the UC Carbon Neutrality Initiative before? (*Yes or no*)

In November 2013, President Janet Napolitano announced the Carbon Neutrality Initiative, which commits UC to emitting net zero heat-trapping greenhouse gases from its buildings and vehicle fleet by 2025, something no other major university system has done. How important is the UC Carbon Neutrality Initiative to you?

- Not at all

- Only a little
- A moderate amount
- A great deal
- Don't know

Is this your first year at UC San Diego? (*Yes or no*)

Did you transfer to UC San Diego from a different College or University? (*Yes or no*)

Where did you attend high school?
- In California
- In another state or territory within the United States
- Outside of the United States

**Supplementary Material, S2—Curricular Requirements**

The minor consists of twenty-eight units of coursework, at least twenty of which must be upper-division. Students must earn at least a letter grade of C- in courses used for the minor, with the exception of 199 courses or other courses that are only offered for a "P/NP" grade.

**CLIMATE CHANGE STUDIES MINOR CURRICULUM**

***1. CLIMATE CHANGE: SOLUTIONS***

a. Required Course. Students ***choose one*** of the following courses:

| | |
|---|---|
| SIO 109/POLI 117 | Bending the Curve: Solutions to Climate Change *(recommended)* |
| ESYS 103/MAE 124 | Environmental Challenges: Science and Solutions |
| BIBC 140 | Our Energy Future—Sustainable Energy Solutions |

***2. CLIMATE CHANGE: UNDERSTANDING THE SCIENCE.***

a. Required Course. Students ***choose one*** of the following two courses:

| | |
|---|---|
| SIO 25 | Climate Change and Society |
| SIO 117 | The Physical Basis of Global Warming *(recommended for students in science, math, or engineering majors)* |

b. Climate change science elective. Students select ***at least one*** of the following electives:

| | |
|---|---|
| SIO 10 | The Earth |
| SIO 20 | The Atmosphere |

| | |
|---|---|
| SIO 35 | Water |
| SIO 40 | Life and Climate on Earth |
| SIO 50 | Introduction to Earth and Environmental Sciences |
| BILD 18 | Human Impact on the Environment |
| ESYS 10 | Introduction to Environmental Systems |
| ENVR 30 | Environmental Issues: Natural Sciences |
| BIBC 140 | Our Energy Future—Sustainable Energy Solutions *(if not already used for requirement 1.a. above)* |
| BIEB 174 | Ecosystems and Global Change |
| BIEB 182 | Biology of Global Change |
| CHEM 171 | Environmental Chemistry I |
| CHEM 172 | Environmental Chemistry II |
| CHEM 173 | Atmospheric Chemistry |
| ESYS 102 | The Solid and Fluid Earth |
| ESYS 103/MAE 124 | Environmental Challenges: Science and Solutions *(if not already used for requirement 1.a., above)* |
| MAE 118 | Introduction to Energy Systems |
| MAE 119 | Introduction to Renewable Energy: Solar and Wind |
| MAE 120 | Introduction to Nuclear Energy |
| MAE 122 | Flow and Transport in the Environment |
| SIO 108 | Introduction to Paleoclimatology |
| SIO 115 | Ice and the Climate System |
| SIO 116 | Climate Change & Global Health: Understanding the Mechanisms |
| SIO 117 | The Physical Basis of Global Warming *(if not already used for requirement 2.a., above)* |
| SIO 143 | Ocean Acidification |
| SIO164/ANAR 164 | Maritime Archeology |
| SIO 173 | Dynamics of the Atmosphere and Climate |
| SIO 174 | Chemistry of the Atmosphere and Oceans |

***3. CLIMATE CHANGE: SOCIAL AND HUMAN DIMENSIONS***.

a. Social and human dimension electives. Students ***must choose two*** of the following courses:

| | |
|---|---|
| SOCI 30 | Science, Technology, and Society |
| COMM 171 | Environmental Communication |
| ECON 131 | Environmental Economics |
| ECON 132 | Energy Economics |
| ETHN 102 | Science and Technology in Society: Race/Gender/Class |
| ETHN 103 | Environmental Racism |
| HISC 180 | History of Science Policy |
| MGT 166 | Business Ethics and Corporate Responsibility |
| MGT 167 | Social Entrepreneurship |

| | |
|---|---|
| PHIL 148 | Philosophy and the Environment |
| POLI 102L | The Politics of Regulation |
| POLI 104E | Environmental Law and Policy |
| POLI 104P | Science, Technology, and the Law |
| POLI 162 | Environmental Policy |
| PSYC 104 | Social Psychology |
| PSYC 137 | Social Cognition |
| PSYC 148 | Psychology of Judgement and Decision |
| SIO 109/POLI 117 | Bending the Curve: Solutions to Climate Change *(if not already used for requirement 1.a., above)* |
| SIO 114 | The Science and Analysis of Environmental Justice |
| SOCI 149 | Sociology of the Environment |
| SOCI 168E | Sociology of Science |
| SOCI 171 | Technology and Science |
| USP 124 | Land Use Planning |
| USP 170 | Sustainable Planning |
| USP 171 | Sustainable Development |

***4. CLIMATE CHANGE: PRACTICUM***

a. Required Courses: Students take ***both of the following 2-unit courses***.

| | |
|---|---|
| CCS 101 | Carbon Neutrality Initiative at University of California (2 units) |
| CCS 102 | Research Perspectives on Climate Change (2 units) |

b. Climate change practicum electives. Students select ***at least 4 units*** from the following options:

| | |
|---|---|
| CCS 190 | Carbon Neutrality Internship (1-4 units) *Prerequisites: CCS 101 and CCS 102.* |
| CCS 199 | Supervised Independent Study or Research (1-4 units) *Prerequisites: CCS 101 and CCS 102.* |

Other departmental internship or independent study courses can be approved for this practicum elective, by petition, if the student work was focused on research, projects or internships related to climate change.

**Rational and course descriptions for proposed new courses**

An intended hallmark of the climate change studies minor is the practicum requirement, in which students learn about carbon neutrality initiatives and climate change research on campus (proposed here as CCS101 and 102), and then complete an applied project relevant to their major or interests. The applied project can be taken for CCS 190 or CCS 199 credit, as proposed

here, or in other departmental internship or independent study courses that consist of research, project-based work, or an internship related to climate change.

**CCS 101. Carbon Neutrality Initiative at University of California (2 units)**
The UC wide goals of the Carbon Neutrality Initiative are introduced through a series of modules where students learn basic principles of carbon neutrality, participate in seminars with campus operations staff and tour relevant campus infrastructure including the UC San Diego microgrid, LEED-certified buildings, and sustainable transportation efforts. *Prerequisites: none.*

**CCS 102. Research Perspectives on Climate Change (2 units)**
This course introduces students to exciting and current research topics related to climate change as presented by faculty and researchers across UC San Diego. The course is offered as a series reading topics followed by seminars on original research presented by faculty and researchers. *Prerequisites: none.*

**CCS 190. Carbon Neutrality Internship (1-4 units)**
A campus-based internship, typically designed by the student, that will help the university meet our stated Carbon Neutrality goals. The project can be developed either individually or as part of a team. A written contract involving all parties will include learning objectives, a paper/project outline, and means of supervision and progress evaluation. Consent of faculty adviser and program chair required. *Prerequisites: CCS 101 and CCS 102.*

**CCS 199. Supervised Independent Study or Research (1-4 units)**
Independent reading or research on a topic related to climate change. By special arrangement with a faculty member.