



**Union of Concerned Scientists**

Citizens and Scientists for Environmental Solutions

# **Confronting Climate Change in California**

**Ecological Impacts on the Golden State**

## **Curriculum Guide for High School Courses in Biology, Geography, Science, Earth Science and others focusing on the society-environment interface**

Developed by the Union of Concerned Scientists  
to accompany the 1999 UCS/ESA report  
“Confronting Climate Change in California”

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## Overview and Invitation

This curriculum guide was developed to accompany *Confronting Climate Change in California: Ecological Impacts on the Golden State*—a report jointly produced by the Union of Concerned Scientists (UCS) and the Ecological Society of America (ESA) in 1999. *Confronting Climate Change in California* was co-authored by nationally and internationally renowned climate scientists and ecologists based in California. Written in a readily accessible and attractive manner for the general public, the report is also appropriate for state and national policymakers and business leaders. The report is intended to raise awareness and understanding of global warming and its potential impacts on the environment Californians love and depend upon, in the hopes that decisions affecting the environment would be better informed in light of this global threat.

This guide is meant to accompany our 1999 California report. A new report on California's climate change was released in 2004, *Climate Change in California: Choosing Our Future*, and is included in your packet. This report looks at two possible future scenarios, a high- and low-emissions scenario. The report and its findings can also be found on the interactive web site <http://www.climatechoices.org>.

Through a generous contribution, the Union of Concerned Scientists was able to extend the reach of the report to future generations of Californians who will have to deal with the impacts of climate change. The resulting curriculum guide consists of a set of eight activities, which are closely tied to and build upon, the report. The teaching materials are geared towards students and teachers in grades 9-12, although individual exercises are adaptable to different grade levels. To make these engaging, student-centered activities most useful to teachers, we adhered to three guiding principles in designing each activity:

1. Tie each activity to the content and skills standards required for grades 9-12 according to the California Board of Education Standards for Science, and History and Social Science (see <http://www.cde.ca.gov/ci/>)
2. Provide sufficient background information and resources for teachers to feel comfortable teaching this complex, and frequently controversial, topic.
3. Offer several alternatives and/or extensions to each activity to facilitate their application in varying teaching contexts—e.g. class size, available resources, grade level, skill level, subject matter, etc.

Global change will affect every Californian, every part of the environment and our natural resources, and thus practically every aspect of our lives—the economy, our urban and suburban development patterns, natural areas we protect, and our life styles. Thus, every subject matter in high school offers opportunities to create linkages to climate change. You may use the entire set of activities or select only some of the activities. We encourage you to adapt them to your specific circumstances. You may, for example, want to focus more specifically on the physical or chemical aspects of atmospheric change; emphasize more strongly the ecological impacts or the economic or social implications; or encourage a critical discussion of the ethical side of this global phenomenon, including the political and technological challenges in finding solutions. This curriculum guide

aims to help make these linkages and adaptations, but the suggestions, instructions, and resources leave each teacher much freedom and require that the activities be adapted for the specific needs of your students.

Additional copies of the report can be downloaded in pdf format from the UCS web site at <http://www.ucsusa.org>. This file contains the complete report text and accompanying color graphics that may be useful for teaching your class. If you reproduce the graphics for use in your class, we ask that you acknowledge UCS and ESA as the source.

The activities in this guide draw on other global change teaching resources built on the principles of active pedagogy—that is, student- and learning-centered, interactive ways of acquiring knowledge. Several experienced educators and curriculum developers have already reviewed this guide. We are interested, however, in making these activities as readily useable and useful as possible, and so welcome and invite your feedback based on actual classroom use. A feedback form is enclosed, and we would much appreciate your taking a few minutes to fill it out and return it to the address on the cover page.

If you enjoy this curriculum guide, we invite you to explore the UCS web site for other teaching materials (<http://www.ucsusa.org>) and to bring them to the attention of your colleagues. We are planning to develop more teaching materials in the future. Should you have any questions or suggestions, please contact Jason Mathers at the address provided on the cover page.

# Curriculum Guide

## Activity 1: Warming Up to Global Warming – What Is It and Why Should I Care?

### **Objectives**

- To raise awareness of global warming as one of the biggest scientific and political challenges of our times.
- To build an understanding for the controversies surrounding the topic of climate change.
- To develop a healthy critical perspective in students as they read and hear about climate change.

### *California Social Science Analysis Skills* n of evidence

- and point of view
- Analysis of social and environmental problems and domestic policy challenges
- Scope and limits of rights and obligations as democratic citizens
- Values and principles of civic society

### **Specific Skills**

- Media observation (following newspaper and other media coverage)
- Critical thinking
- Group discussion (listening, formulating arguments, debating, finding consensus)

### **Materials**

Access to newspapers, radio, TV, magazines, possibly also the web

### **Time**

1 class session

Additional time outside the classroom searching and reviewing news coverage on global warming

### **Background Information**

This activity is particularly recommended for students who are relatively unfamiliar with the issue. It can be used in combination with any of the other activities in this set. For teachers unfamiliar with the topic, we recommend several resources to prepare and to become familiar with the basic scientific and political issues and controversies involved. You may also want to review some scientific, governmental, and climate contrarian web sites—see Appendix and Additional Resources below—and to follow the news for a while (and/or review recent news coverage at the informational climate change sites listed in the Appendix). This will provide you with sufficient background on where the science stands at present, who the “skeptics” are, who the environmental advocacy groups are, which interests they represent, and what is being done in industry and in national and international politics about global warming.

**Key teacher resources**

Objective, succinct, easily accessible and readable background information include the following:

- 1) Office of Science and Technology. 1998. *Climate change: State of knowledge*. Washington, DC. (Also available at <http://www.usgcrp.gov/usgcrp/nacc/default.htm>)
- 2) UCAR/JOSS and NOAA/Office of Global Programs. 1997. *Report to our nation: Our changing climate*. Washington, DC.
- 3) IPCC. 1995. *Climate change 1995: The science of climate change. Summary for policymakers* (Contribution of Working Group I to the Second Assessment Report). WMO, UNEP. (Available at <http://www.unep.ch/ipcc/pub/reports.htm>)
- 4) IPCC. 1995. *Climate change 1995: Impacts, adaptation, and mitigation. Summary for policymakers* (Contribution of Working Group II to the Second Assessment Report). WMO, UNEP. (Available at <http://www.unep.ch/ipcc/pub/reports.htm>)
- 5) United Nations Environment Program. *Vital Climate Graphics*. (available at <http://www.grida.no/climate/vital/> )

**Activity Guide**

Ask students to observe current, and to research past, news coverage (say over the past year) on global warming. Ask them to make lists of the topics covered (new scientific discoveries, national and international political developments, discussion of climate change impacts, etc.), the people interviewed, the general positions they hold, and so on. Students should bring those to the class session as background.

Pick one recent news item, and explore it together in the same fashion in class. Ask students to summarize what all this global warming news is about—what’s the issue? what’s at stake?—and why it seems to make such waves in the news—what are the scientific uncertainties? why are they so hard to resolve? how do new discoveries revise our knowledge base? who are the different interest groups involved in the debate and what is at stake for them?

Ask students to formulate what they think about the issue, whether they care about the debate, or about climate change. Why or why not? Help them identify what is at stake for them personally. Also help them identify why different interests have such opposing views. Conclude the class with a discussion (and resolution) of how best to approach information about climate change (careful, critical, etc.).

**Additional Resources**

- Many climate contrarians have elaborate web sites. Examples include:
  - 1) Center for the Study of Carbon Dioxide and Global Change at <http://www.co2science.org/>
  - 2) The Science & Environmental Policy Project at <http://www.sepp.org/>
  - 3) The Greening Earth Society at <http://www.greeningearthsociety.org/>
- Several web sites aim at sorting out the controversial issues debated in the media. See for example:

- 1) Environmental Protection Agency at <http://www.epa.gov/globalwarming/index.html>
- 2) UNEP/WMO at <http://www.gcrio.org/ipcc/qa/>
- 3) PBS: “What’s up with the weather?” at <http://www.pbs.org/wgbh/warming/>
- 4) The Union of Concerned Scientists’ *Climate Change in California: Choosing Our Future* <http://www.climatechoices.org>

**Activity 2: Understanding Climate Change –  
The Greenhouse Effect and How Humans Contribute to It**

**Objectives**

- To understand the basics of global climate change, including the difference between natural and enhanced greenhouse effect
- To appreciate the importance of the atmosphere for life on Earth
- To appreciate how minor changes in the composition of the atmosphere change the effectiveness of the global greenhouse
- To understand California’s and students’ personal contribution to global warming

**California Science Standards**

- Biology: Basic principles of Ecology (#6 a, b, d, f and g)
- Earth Science: Energy in the Earth System (#4 a-d; #5a, d-g; #6a-d)
- Earth Science: Biogeochemical Cycles (#7a, b, d)
- Earth Science: Structure and Composition of the Atmosphere (#8 a, b)

**Specific Skills**

- Conceptual, analytical, and critical thinking
- Making connections across scales
- Basic mathematical calculations
- Reading comprehension

**Materials**

- See the Appendix for reproducible figures of the greenhouse effect (as hand-outs or overheads).
- For Activity extension #1, students require access to the web.
- For Activity extension #2, students may require calculators, but calculations are simple and can be done “by hand.”

**Time**

1 class session or less, depending on science background and existing knowledge of climate change.

**Background Information**

- Students read Chapter 1 of *Confronting Climate Change in California*.

- The teacher should decide, based on the existing knowledge and understanding of climate change among students, whether to supplement this chapter with one or more additional short readings from the sources provided under Additional Resources.

### ***Activity Guide***

Acquaint students with the basic components of the atmosphere, its structure and composition. Then walk students step by step through the basic processes underlying the greenhouse effect and the radiative budget. (See Figure section in Appendix.) Explain to students how much colder it would be on Earth if there was no natural greenhouse effect, how life could not have evolved on Earth if there were no greenhouse effect. If available, take students to a near-by greenhouse to make the global greenhouse effect more tangible (a classroom window may serve as a proxy). Alternatively, build a little greenhouse in the classroom (e.g., plastic bag over an indoor plant, taking temperatures in and outside of the bag; see additional Teaching Resources on Global Change in the Appendix). Help students understand which human activities produce gas emissions that enhance the natural greenhouse effect.

### ***Extension 1: Personal contributions to climate change***

Students estimate how much CO<sub>2</sub> they personally contribute to the atmosphere every year. The activity can be made more difficult by estimating the student's family's contribution. One web-based climate change calculator is available at [http://www.climcalc.net/eng/Intro\\_1.html](http://www.climcalc.net/eng/Intro_1.html) (note the underscore “\_” between Intro and 1). (See Additional Resources for an alternative.)

### ***Extension 2: Contributions from California's cars alone***

Provide students with the following information:

- a) Number of registered cars in California (or a subregion, e.g., the Bay area) (see Additional Resources for further information)
- b) Current cost of gasoline (average in the Bay area)
- c) Average gas mileage of a vehicle (25 miles per gallon)
- d) Approximate vehicle length (15 feet)
- e) Average miles driven per vehicle per year (12,000)
- f) Pounds of CO<sub>2</sub> produced per gallon of gasoline (~20 lbs.)

You may let students estimate some of these numbers to enhance the “aha!” effect.

Ask students to calculate several figures based on these variables:

1. Estimate how long a line of cars would be (in miles) if all cars of California were stuck “bumper to bumper” on a highway at the same time.  
[number of cars] \* [car length/car] \* [1 mile/5280 feet] = [miles of “car string”]
2. Using an atlas, compare how far this line of cars would stretch across the country or around the globe. (Compare, e.g., to the circumference of the Earth at the equator.)
3. If each of CA's cars travels 12,000 miles/year, how much gasoline is used per year?  
[number of cars] \* [12,000 miles/year] \* [1 gallon/25 miles] = [gallons of gas used]
4. What would be the total cost for all the gasoline used?  
[gallons of gas used] \* [average price of gas/gallon] = [total gasoline cost]
5. How much carbon dioxide is produced by these vehicles?



$$[[\text{gallons of gas used}] * [20\text{lbs CO}_2/\text{gallon}] = [\text{total amount of CO}_2]]$$

You may go one step further. Explain to students the concept of carbon sequestration (uptake of carbon from the atmosphere and long-term storage in trees, soils, oceans, or underground). (See Additional Resources.) Then ask students to calculate how many trees would need to be planted to absorb this amount of CO<sub>2</sub> every year. [Note: Per every 500 gallons of gas, about 15 trees need to be planted to absorb the emitted CO<sub>2</sub> (about 10,000 pounds).]

### **Additional Resources**

- A very comprehensive, science-based climate change information web site. The first section is focused on understanding the basics of global warming and the greenhouse effect; later sections deal with trends, modeling, impacts, and adaptation options – [http://www.pacinst.org/topics/global\\_change/](http://www.pacinst.org/topics/global_change/)
- A clear explanation of the natural and enhanced greenhouse effect, and additional information and graphics (from the Australian Consortium of Scientific and Industrial Research Organizations, CSIRO) – <http://www.dar.csiro.au/cc/default.htm>
- A beginner’s guide to understanding the greenhouse effect from the Woods Hole Research Center – <http://www.whrc.org/globalwarming/warmingearth.htm>
- An alternative Personal Climate Change calculator can be found at <http://www.americanforests.org/shaklee/carbcalc.php3>. The site contains information on how many trees would be needed to sequester a given amount of emitted CO<sub>2</sub>.
- Statistics on the number of registered vehicles in the state can be obtained from: [http://my.ca.gov/state/portal/myca\\_homepage.jsp](http://my.ca.gov/state/portal/myca_homepage.jsp) (on the “Quick Hits” side bar (lower right) select “California Facts,” then select “Transportation”)
- The Union of Concerned Scientists’ *Climate Change in California: Choosing Our Future* <http://www.climatechoices.org>

## Activity 3: Know Thy Home – California’s Unique Ecosystems

### **Objectives**

- To understand the concepts of ecosystem and biome
- To understand and articulate the relationship between climate and biome
- To gain an initial understanding of landscape change
- To appreciate (personal) benefits from California (local) ecosystems

### **California Science Standards**

- Biology: Basic principles of Ecology (d g)

### **California Social Science Analysis Skills**

- Chronological thinking
- Relating current events to characteristics of places and regions
- Historical interpretation of human modification of landscapes

***Specific Skills***

- Map reading and interpretation
- Data gathering
- Working collaboratively
- Analytical thinking
- Oral reporting

***Materials***

- Map of California biomes (See also Additional Resources.)
- Atlas of California, preferably including historical maps
- *Confronting Climate Change in California* Report
- Optional access to internet for information gathering on specific biomes (See Additional Resources for examples of relevant web sites.)

***Time***

1-2 class sessions, possibly with some homework between sessions or afterwards

***Background Information***

Students read Chapters 2 and 3 of *Confronting Climate Change in California*.

***Activity Guide***

This activity depends in part on the context in which students live. Inner-city or urban students may find it difficult to name, and describe experiences in, natural places. Teachers must judge from their knowledge of students' lives and the range of plausible life experiences they might have had whether students should begin this activity from option 1 or 2.

Then begin the activity in one of two basic ways: (1) by asking students to name (and locate on a California map) their favorite natural places to visit, hike, explore, etc. Ask them about the places where they have already been, what they looked like, what they liked and remembered about them—guiding them toward talking about the environment (landscape features, bodies of water, vegetation, animals they observed, particular weather patterns they experienced, general climate, etc.). Or (2) by using historical maps, possibly movies depicting California before significant urban development, books, nature writing, old photographs, and/or their imagination to visualize the “natural California” that once was. Discuss with them the ways in which humans have altered the landscape, what has been lost and what has been gained. (See also Extension 1 below.)

Then introduce the concepts of ecosystem and biome to the students (using any biological textbook), and help them name and identify biomes in California (using a map or atlas of California). Split the class into several groups (up to four students per group), each one responsible for gathering additional information on a particular biome. Students can use maps, an atlas, or the web for this information search. On a hand-out (see Appendix), students compile information on annual average temperature and temperature range, precipitation totals and seasonal distribution, soil characteristics, typical vegetation/plant communities (possibly along elevation gradients), and characteristic or unique animals.

(The compiled information can be made available to every student.) Once students have all needed information, they present a profile of the biome to the rest of the class. Ask students to rank the biomes by temperature and secondarily by precipitation to help them draw out the specific relationship between the type of climate and the particular biome that evolved under those circumstances.

***Extension 1: Guidebook to Natural Places***

To engage students more creatively and hone their analytic and writing skills, you may extend this activity by asking students to collectively prepare a guidebook to the “best natural places in California” (or more locally). This can be done in a number of ways—very personal, experiential and fun, or more scientific, involving extra research on the natural history and ecology of these places. (See Additional Resources.)

***Extension 2: Class discussion***

This extension may be a good follow-up to the second option described above for how to begin this activity. Based on the information gathered about the natural environment, students brainstorm the benefits they personally, or society at large, derives from these biomes. Then they discuss the implications of human impacts on the biomes (as discussed in Chapter 3 of the CA report). Students should get a good understanding of the complexity of the human-environment interaction. There are many benefits we derive from unaltered natural environments—so-called “ecosystem services” such as natural flood control, carbon sequestration, pollination, water and air purification, aesthetic pleasure, etc. We also gain much from managing the environment for specific purposes—forestry, agriculture, urban areas, transportation, etc.—although frequently our use and manipulation of the environment produces negative consequences as well. (See Additional Resources.)

***Additional Resources***

- A guide to biotic zones in California and their dominant plant communities – <http://www.calpoly.edu/~dchippin/zonation.html>
- CA Environmental Resources Evaluation System – <http://ceres.ca.gov/index.html>
- The Union of Concerned Scientists’ *Climate Change in California: Choosing Our Future* <http://www.climatechoices.org>
- CA Biodiversity Council – <http://ceres.ca.gov/biodiv/>
- National Forests in California (USDA Forest Service) – <http://www.fs.fed.us/r5/forests.html>
- Mojave Desert Ecosystem Program (DoD, DoI-USGS) – <http://www.mojavedata.gov/>
- Tahoe Basin Data Clearinghouse – <http://tahoe.usgs.gov/>
- Recoverability and Vulnerability of Mojave Desert Ecosystems (USGS) – <http://wrgis.wr.usgs.gov/MojaveEco/index.html>
- California Native Plant Society has a variety of relevant resources – <http://www.cnps.org/>
- California Wildlife Habitat Relationships lists all species in California and describes their geographic distribution and relationship to particular habitats – <http://www.dfg.ca.gov/whdab/index.html>

- Additional teaching resources are available from the California Board of Education, Office of Environmental Education at <http://www.californiaee.org/>
- Additional information, background information, and resources on ecosystem services can be found at the following sources:
  - Daily, Gretchen (ed.). 1997. *Nature's services: Societal dependence on natural ecosystems*. Island Press, Washington, DC.
  - Costanza, Robert et al. 1997. The value of the world's ecosystem services and natural capital. *Nature* 387: 253-260.
  - In: *Confronting Climate Change in California*, p.12: box on ecosystem services
  - Ecological Society of America. 1997. *Ecosystem services: Benefits supplied to human societies by natural ecosystems*. Issues in Ecology, No.2. ESA, Washington, DC.
  - Union of Concerned Scientists and the Ecological Society of America. *Communicating Ecosystem Services: Tools for Scientists to Engage the Public*. Available at: <http://www.esa.org/ecoservices/>

#### Activity 4: What Could Happen Here? – Exploring Ecosystem Changes

##### **Objectives**

- To understand the basic effects of climatic changes on individual species
- To understand the complex interactions of climatic changes with entire biotic communities
- To gain deeper familiarity with individual species or biomes in the region

##### **California Science Standards**

- Biology: Basic principles of Ecology (#6 a, b, d, f and g)
- Earth Science: Structure and Composition of the Atmosphere (#8 a, b)

##### **California Social Science Analysis Skills**

- spatial thinking
- Relating current events to characteristics of places and regions

##### **Specific Skills**

- Essay or research report writing
- Basic research skills (data gathering through interviews, web or library searches, analysis and presentation of findings)
- Critical thinking
- Class discussion (argument formulation, oral expression, listening, etc.)

##### **Materials**

None specifically; depends on adaptation of activity

##### **Time**

Adaptable from 1 to several class sessions; additional time for homework

**Background Information**

Students read Chapter 4 of *Confronting Climate Change in California* and should be familiar with Chapters 1-3.

**Activity Guide**

Recall the climate projections from Chapter 1 of the report to (re)familiarize students with some of the basic changes to be expected with global warming in CA—increase in CO<sub>2</sub>, temperature increase, precipitation changes, increase in freshwater and ocean temperatures, sea-level rise, changes in storminess, fire regimes, etc. Examine with students what these types of changes in principle would mean for plants, insects, fish, birds, large wildlife, etc. Let them brainstorm, speculate, analyze, and recall from their reading of the report what types of changes might be expected—e.g. species range shifts to higher and more northern locations, species extinction, changing productivity, vulnerability to pests, diseases, fire etc. To deepen students' understanding, use one or more specific species as examples (e.g., those provided in *Confronting Climate Change in California*) to explore and illustrate these effects. Ask students to discuss what the ramifications of these changes would be for them personally, for the Bay area, for California as a whole, or even beyond.

**Extension: Essay**

Ask students to write a short essay after the in-class data gathering work (in Activity 3) and the above discussion on selected aspects of the relationship between biome and climate. (See the objectives above for possible foci for such an essay.) The purpose of this exercise is to deepen the students' understanding gained through previous exercises, and the students may have to do some additional research. How dependent, for example, is the biome on the current climate, or how much change in temperature or precipitation could it cope with? Are there known limits to what species or biomes can cope with? How often does the biome (on average) experience drought, flooding, fire; and what might happen if any of these changed in the future? Do all plants and animals in a biome react in the same way to higher temperatures? And if they don't, how would that affect the interactions among different species?

**Additional Resources**

- Global Change Research Information Office: *Why can't ecosystems just adapt?*  
Available at: <http://www.gcrio.org/ipcc/qa/11.html>
- USGS web-based atlas of the *Relations Between Climatic Parameters and Distributions of Important Trees and Shrubs in North America* is available at: <http://greenwood.cr.usgs.gov/pub/ppapers/p1650-a/>
- The Sierra Club's summary of potential impacts of climate change on wildlife and habitat – <http://www.sierraclub.org/globalwarming/habitat/>
- Additional resources or readings can be selected from an extensive scientific bibliography on climate change impacts on wildlife – <http://www.pacinst.org/wildlife.html>
- For further examples from across the United States of climate change impacts on natural and managed ecosystems, see the short summary guides to the regional and

sectoral impacts examined in the recently released *US National Assessment of the Potential Consequences of Climate Change and Variability* –

<http://www.climatehotmap.org/impacts>

- Climate Protection Institute. 1991. *Global warming: High school science activities*. San Francisco, CA. This somewhat dated but still useful handbook for teachers includes an activity exploring the effects of temperature change on living organisms.
- Additional teaching resources are available from the California Board of Education, Office of Environmental Education at <http://www.californiaee.org/>.
- The Union of Concerned Scientists' *Climate Change in California: Choosing Our Future* <http://www.climatechoices.org>

**Activity 5: Early Warning Signs –  
Searching for Indicators of Climate Change in California**

***Objectives***

- To understand the concepts of climate change “signals” or “fingerprints”
- To identify whether climate change is already apparent in California
- To appreciate environmental resources and amenities
- To understand the concept of “endangered species” and what causes drive endangerment

***California Science Standards***

- Earth Science: Energy in the Earth System (#5, #6)
- Biology: principles of Ecology (#6)

***California Social Science Analysis Skills***

- Chronological and spatial thinking
- Relating current events to characteristics of places and regions
- Research and distinction of evidence and point of view

***Specific Skills***

- Data search
- Interviewing
- Analytical thinking
- Written or oral presentation of findings
- Working cooperatively and collaboratively with classmates

***Materials***

- Readings
- Access to the internet, libraries, and local experts on wildlife and native plants

***Time***

1 class session to explore the notion of climate change signals. The follow-on activity could be assigned as homework and requires one class session to present the findings. Alternatively, the activity could be designed as a longer group project engaging students for some time over the course of the year.

**Background Information**

- Students read Chapters 2 and 4 of *Confronting Climate Change in California*.
- Background information on “indicators” or “fingerprints” of climate change. We recommend two short readings, accessible at <http://www.climatehotmap.org/fingerprints.html> and <http://www.climatehotmap.org/harbingers.html>.
- To stimulate critical analysis and to build an understanding for why there is a debate over the reality of climate change, you may want to work with students using other scientific articles on “early indicators” of climate change as well as views from climate contrarians who maintain that it is not possible to detect climate change or to attribute any causes at this time. Possible sources include:
  - 1) NASA Goddard Institute for Space Studies. *A Common Sense Climate Index: Is Climate Changing Noticeably?* Available at: <http://www.giss.nasa.gov/data/update/csci/>
  - 2) “On the Detection of Climate Change” by Benjamin D. Santer (LLNL, Livermore, USA). We are now close to the threshold of detecting an anthropogenic effect on climate. Discussion at: <http://www.clivar.ucar.edu/exchv1n1p3.html>
  - 3) Additional climate change detection studies are referenced at: <http://www.lmd.jussieu.fr/pcmdi-mirror/pcmdi/detection.html>
  - 4) Contrarian views on the topic are available, for example, at: <http://www.rppi.org/peg3central.html> or <http://www.sepp.org/books/gwubtoc.html> (many others can be explored through their links).

**Activity Guide**

During class time, help students understand—based on the CA report and additional readings—how climate change differs from climate variability, and how one might detect actual climate change against a backdrop of a typically variable climate. Students should understand that not every little year-to-year variation means that the overall climate is changing. Then have individual, or small groups of, students choose a particular environmental resource (e.g., freshwater, oceans, forests), a species mentioned in the CA report, or any other plant or animal typical in the Bay area. They will then learn more about the resource or the species, its habitat, biological and climatic “needs,” and whether recent climatic changes have already had any effects on the resource or species. Students might have to consult experts at local nature conservancies, wildlife preserves, parks, forests or coastal conservancies. Students might interview older residents about changes they might have observed over their lifetimes.

Students should also gather data (e.g., from web sites of state and federal agencies, gathering the relevant information, or from individuals interviewed for the project) on the underlying drivers behind the detected changes. These might include data on air and water temperature changes; precipitation changes; changes in dates of last and first frosts; changes in snow cover; habitat fragmentation or destruction through development, agriculture, other human activities; replacement by invasive exotic species; specific impacts from hunting, fishing, trapping, or other use; etc. Ask students to critically examine whether these underlying causes have indeed brought about the changes for the

resource or species under consideration. Frequently, several causes interact to bring about change.

**Extension: Impacts on already endangered species**

Besides the impacts on common species, climate change is of particular concern with regard to endangered species. Explore with students the reasons why species become endangered and how climate change can aggravate the conditions for species survival. Different students or groups of students can explore some common and some endangered species in the exercise above. (See Additional Resources for relevant data sources and readings.)

**Additional Resources**

- The Union of Concerned Scientists, together with a number of other environmental organizations, has produced a science-based map of “Early Warning Signs” of climate change for the world. This map is available on-line, together with extensive explanations of the choice of indicators and a reference to the scientific literature – <http://www.climatehotmap.org>
- In the United Kingdom, a long-term research project is underway that aims to identify and measure climate change indicators. The study provides many ideas for students as to the kinds of indicators they may look for (and how difficult it is to do so) – [http://www.ecn.ac.uk/Education/indicators\\_of\\_climate\\_change.htm](http://www.ecn.ac.uk/Education/indicators_of_climate_change.htm)
- Index of threatened and endangered plant and animal species (state-listed) – <http://www.dfg.ca.gov/whdab/html/lists.html>
- Federally listed threatened and endangered species – <http://endangered.fws.gov/>
- Czech, Brian, Paul R. Krausman, and Patrick K. Devers. 2000. Economic associations among causes of species endangerment in the United States. *BioScience* 50(7): 593-601. (Note: Some articles in *BioScience* are accessible online – <http://www.aibs.org/bioscienceonline/>)
- Extreme weather events can be used to illustrate the types of impacts that might be expected under climate change scenarios. The US Geological Survey has produced a number of fact sheets of such extreme events – <http://water.usgs.gov/wid/index-hazards.html>

**Activity 6: Climate Change and Me –  
Time Warp to 2050**

**Objectives**

- To make the impacts of global warming real in the context of students’ lives
- To appreciate the uncertainties contained in projections of climate change and its impacts

*California Social Science Analysis Skills*

- Chronological thinking
- Relating current events to characteristics of places and regions
- Historical interpretation of human modification of landscapes



***Specific Skills***

- Essay writing
- Critical and imaginative thinking
- Group discussion (listening, formulating arguments, debating, finding consensus)

***Materials***

- A copy of “The Cascading Effects of Climate Change on California’s Water,” a supplementary material to the report (included in this package).
- P.52 of *Confronting Climate Change in California* “How Confident Can We Be About Future Trends in Climate and Ecosystems?”

***Time***

One class session for explaining and discussing the water impacts and uncertainty charts. Time needed for the completion of assignment depends on scope expected by teacher. The activity can be done as a creative writing assignment, e.g., as homework, or for a year-end project.

***Background Information***

Students should have read Chapters 1-4 of *Confronting Climate Change in California*.

***Activity Guide***

One of the key findings of *Confronting Climate Change in California* pertains to changes in water—one of the most critical resources for the state’s wildlife, cities and residents, agriculture, and other economic sectors. The schematic “Cascading Effects of Climate Change on California’s Water” summarizes the potential impacts. Walk students through the graphic and let them imagine what these changes really mean in the context of their daily lives. (Note, as of December 2000, the graphic is also available at the UCS web site as an interactive feature.) Remind them of recent weather events or observed changes in the environment similar to those projected for the future. Be sure students are able to create a mental image of what their future California will look like. Be sure also that they understand which of the projected changes scientists are highly confident about, and which ones less so. (Use the “Uncertainty Chart” from the CA report, pp. 51–52, to assist this discussion.)

As the assignment, ask students to write an essay on “A day in my life in 2050,” “A vacation to the Sierra Nevada in 2050,” “The opportunities and threats of daily life in 2050,” or some similar topic. Encourage them to be creative and imaginative within the boundaries of the likely climate and societal changes described in the report. Also ask students to record the web sites and other sources they consult in writing their essay, and to evaluate them in terms of scientific credibility. This will allow you to assess whether students are beginning to develop an ability to critically differentiate credible information from fiction and interest-driven propaganda.

***Extension: Group discussion of benefits and losses of such a future world***

The writing assignment can be extended with a group discussion either before or after the writing. A discussion before could serve a brainstorming function, which helps students

to imagine a significantly different future world. A discussion after could serve a debriefing function to let students air emotions about the world they imagined, or to stimulate a discussion about how desirable such a future world may be, and what to do now to influence the course of history.

**Activity 7: Reducing Our Impact on the Global Climate – Possible Solutions**

***Objectives***

- To identify possible solutions that would reduce the amount of greenhouse gases emitted into the atmosphere and thus slow global warming
- To develop an initial appreciation for the complexities of designing and implementing such solutions
- To promote critical understanding of the steps California has taken to date to address the emission of greenhouse gases
- To increase awareness of students' (respons)ibility to contribute to the solution of the problem
- To understand solution-related concepts such as energy efficiency, renewable energy, net reduction of energy use, tailpipe emissions standards, etc.

***California Science Standards***

- Earth Science: Energy in the Earth System (#4, #5, #6)
- Earth Science: Biogeochemical Cycles (#7)
- Earth Science: Structure and Atmosphere (#8)
- Chronological and spatial thinking
- Research and distinction of evidence and point of view
- Historical interpretation of human modification of the environment

***Specific Skills***

- Web search
- Group discussion (listening, formulating arguments, debating, finding consensus)
- Critical thinking
- Rating relative importance of different solutions

***Materials***

- Readings
- Access to the internet

***Time***

Time for web search outside the classroom; 1 class session for discussion and evaluation of options

***Background Information***

- Students should read Chapter 5 of *Confronting Climate Change in California*.
- Students prepare for the class by searching the web for “solutions to the climate problem.” Ask them to read through some of the materials they find, which will help them get better acquainted with the topic of solutions.

***Activity Guide***

Offer students a number of web sites and/or keywords to search for possible solutions to global warming, i.e., to the processes and actions that create this global problem. Each student should come prepared to the next class with a list of at least 10 concrete actions each—anything from personal lifestyle changes to state and national efforts. Collect all suggestions on an overhead, then have students assess the relative importance of each action by voting on each: how many students think the action is “most important,” “somewhat important,” “not very important,” “totally unimportant.” Use this assessment for an in-class discussion of why students think the actions are as important as they believe. Near the end of the discussion, help students come to a consensus on at least the key elements of a “solution package.” You may compare the students’ suggestions to what California has done to date to reduce emissions. During the discussion, ensure that students have a good understanding of solution-related concepts, like “energy efficiency,” “renewable energy,” “zero emission vehicles,” “tailpipe emissions standards,” etc.

***Extension: Commit to one change!***

If students contributed several suggestions for personal life style changes or smaller actions any individual could take, ask them if they would commit to making that change for at least one day, one week, one month, or one school year. If they agree to do so, ask them to keep a “Contributing to the Solution” journal in which they briefly note every day how they are doing. At the end of the agreed-upon period, ask them to write a short summary of their experience. Ask them to be honest so that they can really see how easy or difficult some of these changes would be.

***Additional Resources***

- California’s efforts to reduce Greenhouse gas emissions, see the CA Energy Commission’s web site at [http://www.energy.ca.gov/global\\_climate\\_change/](http://www.energy.ca.gov/global_climate_change/)
  - For suggested actions to reduce GHG emissions see the following small sample of web sites – <http://www.climatechangesolutions.com/>  
<http://www.enviroweb.org/>  
<http://www.cru.uea.ac.uk/tiempo/floor2/educ/diy/diy.htm>  
<http://www.climatehotmap.org/solutions/index.html>
- The number of other web sites on solutions is enormous. Look through any of the Additional Resources in previous activities or in the Appendix for further web sites.
- Additional teaching resources are available from the California Board of Education, Office of Environmental Education at <http://www.californiaee.org>

**Activity 8: Reducing Our Impact on the Local Environment – Possible Solutions**

**Objectives**

- To understand the concepts of “local stresses,” “vulnerability,” “resilience,” “prevention,” “precaution,” and “adaptation”
- To recognize certain human activities as contributors to stresses and vulnerability
- To identify feasible actions to reduce local stresses on the environment

**California Science Standards**

- Biology: Ecology (#6)

**California Social Science Analysis Skills**

- Chronological and spatial thinking
- Historical interpretation of human modification of the environment
- Analysis of social and environmental problems and domestic policy
- Scope and limits of rights and obligations as democratic citizens
- Values and principles of civic

**Specific Skills**

- Small group discussion and team work
- Reading and interpreting cartographic information (thematic maps)
- Critical and analytical thinking

**Materials**

- Atlas of California
- Readings
- Optional access to the internet

**Time**

1-2 class sessions, depending on adaptation of the activity

**Background Information**

- Students read Chapters 3 and 5 of *Confronting Climate Change in California*.

**Activity Guide**

This activity is a good follow-on exercise to previous activities where students became intimately acquainted with various biomes (Activity 2) or species (Activity 3). Recall those examples, and ask students to collect various types of information from the atlas about those areas where the studied species live—i.e., about land use, resource extraction, population density and growth rates, human alteration of the environment (e.g. dams, changes to waterways, roads, hardening of the shoreline, etc.), incidences of air or water pollution, and so on. If available, collect information on the types and sizes of habitats remaining in a given geographic area. Discuss with students how these human activities

affect the biomes, species, and habitats. Those that appear to have negative consequences for the environment will be listed as “local stresses” on the environment.

Now recall the list of potential consequences of climate change on California. Ask students to examine, in small group discussion, how these climatic changes would affect these stressed local environments or species, and ask them to compare the ecosystem responses of a non-stressed and a stressed environment. Support students’ emerging understanding by introducing the concepts of “vulnerability” and “resilience.” Either as homework or continued small-group teamwork, ask students to make separate lists of suggested actions to reduce local stresses.

- List A would be a list of preventative measures (e.g., establish preserves, limit sprawl, reduce or eliminate local pollution).
- List B would be a list of remedial measures to reduce the biomes’/species’ vulnerability (e.g., clean up polluted coastal waters, restore degraded wetlands).
- List C would be a list of reactive measures to help biomes/species to cope with the projected climate changes (e.g., establish migration corridors, plant better adapted species, move species to new locations).

The suggestions should be presented and debated in class.

***Additional Resources***

- The concepts of “vulnerability,” “resilience,” and “adaptation” are used quite differently across different disciplines and over time. As key concepts in the *US National Assessment of the Potential Consequences of Climate Variability and Change* (<http://www.gcrio.org/NationalAssessment/overpdf/overview.html>), the terms are defined there. These definitions are more or less congruent with the usage in the most recent work by the Intergovernmental Panel on Climate Change (e.g., in the Third Assessment Report to be released in 2001).
- Many local environmental groups provide information on needed environmental protection measures. Students could explore the web for such information on the specific species or biome they choose to work on.
- Additional teaching resources are available from the California Board of Education, Office of Environmental Education at <http://www.californiaee.org/>

# Appendix

## References for National Learning Standards Alignment

### **Science**

National Research Council, 1996. *National Science Education Standards*. National Academy Press, Washington, DC.

### **Social Studies**

National Council for the Social Studies, 1994. *Expectations of Excellence Curriculum Standards for the Social Studies*, National Council for the Social Studies, Washington, DC.

### **Geography**

American Geographical Society, Association of American Geographers, National Council for Geography Education, and National Geographic Society, 1994. *Geography for Life National Geography Standards*. National Geographic Research and Exploration, Washington, DC.

### **Technology**

International Society for Technology in Education, 1998. *National Educational Technology Standards for Students*. International Society for Technology in Education (ISTE), NETS Project, Eugene, OR.

### **Environmental Education**

North American Association for Environmental Education, 1999. *Excellence in EE – Guidelines for Learning (K-12)*. North American Association for Environmental Education, Rock Spring, GA.

### **English Language Arts**

*National Council of Teachers of English and International Reading Association, 1996. Standards for the English Language Arts. National Council of Teachers of English and International Reading Association, Urbana, IL and Newark, DE.*

## Annotated List of Selected Web Resources

- The EPA's Global Warming Information Center. Check their "Links" section and the "Annotated summary of climate change resources" – <http://www.epa.gov/globalwarming/index.html>
- This is a very comprehensive, science-based climate change information web site. The first section is focused on understanding the basics of global warming and the greenhouse effect; later sections deal with trends, modeling, impacts, and adaptation options – [http://www.pacinst.org/topics/global\\_change/](http://www.pacinst.org/topics/global_change/)
- For a wide selection of recent scientific studies and news stories on climate change – [http://www.TheEnergyGuy.com/Links\\_ClimateChange.html](http://www.TheEnergyGuy.com/Links_ClimateChange.html)
- One of the most comprehensive, frequently updated information source on global change, put together by the Pacific Institute for Studies in Development, Environment, and Security – [http://www.pacinst.org/topics/global\\_change/](http://www.pacinst.org/topics/global_change/)
- For a policy focus, see The Global Warming Information Center – <http://www.nationalcenter.org/Kyoto.html>
- Additional teaching resources on environmental topics are available from the California Board of Education, Office of Environmental Education at <http://www.californiaee.org/>.

## Additional Teaching Materials on Global Change

- Mortensen, Lynn L. (ed., 1999). Global change education resource guide. NOAA, OGP, Silver Spring, MD – contains a great number of activities and teaching materials on global change in general. Also lists a great number of additional resources.
- Environmental Education on the Internet – <http://www.eelink.net/>
- Classroom of the Future (COTF) program is helping to bridge the gap between America's classrooms and the expertise of NASA scientists (NASA) – <http://www.cotf.edu/>
- Another NASA site is the Teaching Earth Science web site – <http://www.earth.nasa.gov/education/index.html>
- The Virtual Geography Department is a gateway to numerous relevant teaching materials. Click on "Earth's Environment and Society" and then on "Other resources" – <http://www.colorado.edu/geography/virtdept/contents.html>
- EPA's Environmental Education Resource Center – <http://www.epa.gov/teachers/>
- American Association of Geographers: Hands-on Teaching Modules on the Human Dimensions of Global Change (for undergraduate college, but easily adapted to high school level) – [http://www.aag.org/HDGC/Hands\\_On.html](http://www.aag.org/HDGC/Hands_On.html)
- Watershed Education Resources – <http://www.green.org/resources/>
- Earth System Science Education (online) provides access to all federal agencies, research institutes and other organizations providing educational resources on the environment. A treasure trove – <http://www.usra.edu/esse/essonline/>
- EPA's Student Center – [www.epa.gov/region5/students/](http://www.epa.gov/region5/students/)

**Worksheet: California's Climate and Characteristic Biomes**

In your group, find the following information for the biome you are working on. Then compare your biome profiles.

**Biome name:** \_\_\_\_\_  
\*\*\*\*\*

**Temperature:**  
What is the annual average temperature? \_\_\_\_\_

What is the seasonal temperature range (what are the coldest/warmest average temperatures and in which months does each occur?)  
Warmest: \_\_\_\_\_  
Coldest: \_\_\_\_\_

Difference: \_\_\_\_\_

What is the daily temperature range? \_\_\_\_\_

Which range is larger—the seasonal or the daily temperature range?  
\_\_\_\_\_

**Precipitation**  
What is the annual average precipitation total? \_\_\_\_\_

Which are the driest months and which are the wettest months, and what are their precipitation totals?  
Driest: \_\_\_\_\_ Total \_\_\_\_\_  
Wettest: \_\_\_\_\_ Total \_\_\_\_\_

How big is the difference in monthly precipitation totals between the driest and the wettest month?  
Difference: \_\_\_\_\_

**Rocks and soils**  
What types of rocks are typical in this region? \_\_\_\_\_  
\_\_\_\_\_

What can these rocks be used for? \_\_\_\_\_

What types of soil are typical in this region? \_\_\_\_\_  
\_\_\_\_\_

What can these rocks be used for?  
\_\_\_\_\_

**Ecosystems**  
Typical vegetation/plant communities  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

Characteristic or unique animals  
\_\_\_\_\_  
\_\_\_\_\_



## Figure References

Figures to illustrate concepts and systems referred to in this curriculum guide are available from many sources, some of which are restricted in terms of reproduction due to copyright protection. Generally, graphics produced and published by federal and state government agencies are not restricted in this way.

Thus we suggest as supporting graphics to illustrate the greenhouse effect and emission and temperature trends the following source:

The White House. 1998. *Climate Change: State of Knowledge*. Washington, DC. This publication is readily available on the web at <http://clinton5.nara.gov/Initiatives/Climate/content.html>.

The figures can be freely reproduced with acknowledgement.

Supporting graphics for potential impacts on water resources in California and regional summaries of impacts on ecosystems in California were produced by UCS and are included in this package. In December 2000, UCS will have these supplementary materials as interactive features on our web site (<http://www.ucsusa.org>).

## Evaluation Form

We would greatly appreciate your feedback on the Curriculum Guide accompanying the report *Confronting Climate Change in California: Ecological Impacts on the Golden State*.

***In what type of course did you use the guide?***

- Biology
- Science
- Geography/Earth Science
- Social Science
- Other \_\_\_\_\_
- I did not use the guide

***At what grade level did you use the materials?***

- 9<sup>th</sup> grade
- 10<sup>th</sup> grade
- 11<sup>th</sup> grade
- 12<sup>th</sup> grade
- Other \_\_\_\_\_

***Which activities did you use (including adapted versions of provided activities and extensions) (check all that apply)?***

- |                                     |                                      |   |                                    |
|-------------------------------------|--------------------------------------|---|------------------------------------|
| <input type="checkbox"/> Activity 1 | <input type="checkbox"/> Extension 1 | <input type="checkbox"/> Activity 5     | <input type="checkbox"/> Extension |
| <input type="checkbox"/> Activity 2 | <input type="checkbox"/> Extension 2 | <input type="checkbox"/> Activity 6     |                                    |
| <input type="checkbox"/> Activity 3 | <input type="checkbox"/> Extension 1 | <input type="checkbox"/> Activity 7     | <input type="checkbox"/> Extension |
|                                     | <input type="checkbox"/> Extension 2 | <input type="checkbox"/> Activity 8     |                                    |
| <input type="checkbox"/> Activity 4 | <input type="checkbox"/> Extension   | <input type="checkbox"/> All activities |                                    |

***If you modified the activities, please briefly describe how.***

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***Overall, how useful was the curriculum guide in your teaching?***

- Very useful
- Useful
- Somewhat useful
- Not useful

***Did you find the content and skill objectives appropriate for students in your class?***

- |                   |                                     |  |                                   |
|-------------------|-------------------------------------|--|-----------------------------------|
| <i>Objectives</i> | <input type="checkbox"/> just right | <input type="checkbox"/> too difficult | <input type="checkbox"/> too easy |
| <i>Skills</i>     | <input type="checkbox"/> just right | <input type="checkbox"/> too difficult | <input type="checkbox"/> too easy |

***Was the logistical information provided accurate, up-to-date, and sufficient?***

Time requirements

- accurate
- insufficient
- overestimated

Please specify actual time needed for the activities you used \_\_\_\_\_

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Material requirements

- accurate                       insufficient                       overestimated

Please specify materials needed not mentioned in the guide \_\_\_\_\_

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Background information

- accurate                       insufficient                       overdone

Please specify information needed not mentioned in the guide \_\_\_\_\_

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Additional resources

- useful                       insufficient                       web links no longer live

Please specify resources needed not mentioned in the guide \_\_\_\_\_

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**What additional information would have made the guide more useful?**

- More resources
- More detailed description of procedure
- Other (please specify) \_\_\_\_\_
- 
- Resources other than web sites (please specify) \_\_\_\_\_
- 

**Do you have any additional feedback for us on the curriculum guide?**

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Thank you for taking the time to evaluate this curriculum guide. UCS will use this information to update and revise the guide as appropriate. We will also use your feedback in the design of other teaching materials we may produce in the future.

Please return this evaluation form to:

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