LP 5 Consequences on Biological Systems & Adaptation

# of Days	3		
Prior Knowledge		California English-Language Arts Content Standards	Reading 2.0, 2.5 Listening and Speaking 1.3, 2.5
Lesson Objective	Students will analyze data to determine the consequences of climate change on environmental, biological, human, and social systems and identify adaptation strategies for these consequences.	Language Goals/Demands	Make sure students understand meaning of adaptation, system, biological, environmental, and social, density, displacement
Lesson Assessment	Students will generate and share adaptation strategies for dealing with the impact of climate change on biological systems	Changes for Next Time	
California State Science Standard	Biology 6.b, 6.g; Earth Science 6.b.; Investigation 1.a, 1.d, 1.m		
Materials Needed	LP 4 Quiz; Materials for sea level activity - clear containers, cubes of ice, clay, rulers; materials (data and graphs) for stations	What Worked Well	

Time	Learning Task or Activity	Method & Notes
Day 1		
3 min	BW: Make a list of positive and negative impacts of climate change	INDIVIDUAL SEAT WORK (5.1.1)
5 min	Discuss Bellwork - Ask students to share different consequences for humans or the environment - End by talking about sea level rise as an important consequence for coastal areas like the Bay Area. - Also remind students of ALBEDO: different materials/surfaces have different level of reflectivity.	LECTURE/DISCUSSION See 5.1.1 Consequences Slides
10 min	Begin Sea Level Activity - Students will set up Sea Level Activity (in small groups) and record initial observation of water level (outside if possible)	HANDS-ON ACTIVITY See 5.1.4 Sea Level Activity Instructions and Datasheet Students set up activity using task card.

15 min	Quiz over LP 4	INDIVIDUAL SEAT WORK Use 5.1.2 LP4 Quiz and Key Make second observation of ice after quiz
20 min	Sea Level Activity Continued - Have students make 2 more observations (at 20 and 30 min) -Teacher lead discussion (based on preliminary observations). What has occurred? What is different? What is the same between the two conditions? What are the scientific principles behind this phenomena? - Students make final observations (measure water level)	HANDS-ON ACTIVITY CONTINUED See 5.1.3 Ice Activity Instructions and Datasheet.doc Students check every 10 minutes, recording results on table. Have students work with groups to discuss and answer questions. Conclude with a whole group discussion.
HW	Homework What are some of the factors that contribute to sea level rise? What areas will be most affected?	
Day 2		
2 min	BW: We recently looked at graphs of sea level rise. If this pattern continues, what parts of the Bay Area will be affected?	INDIVIDUAL SEATWORK
5 min	Introduction to idea of Adaptation: We've looked at some of the impacts of climate change, one example is sea level rise. What are some things we can do to prevent more damage from climate change? The changes and adjustments we make are "adaptations".	DISCUSSION Review mitigation (introduced in earlier lessons). Introduce idea of adaptation. Create a KWL (what we KNOW, what we WANT to know, and what we LEARNED (this column is filled in later)) about adaptation.
10 min	We've talked about Physical systems (past lessons, now we're going to look at the IMPACT OF CLIMATE CHANGE ON BIOLOGICAL SYSTEMS) Station 1: Ecosystems Station 2: Agriculture Station 3: Fire on Wildlands Station 4: Global Health and Disease	GROUP WORK Students will rotate between 4 stations. Each station will have data, pictures, and graphs showing the consequences of climate change on each topic. Students have a list of questions about adaptations. Use 5.2.1 Sample Evidence Claim Use 5.2.2 Station Task Cards Use 5.2.3 Student Questions Use 5.2.4 Station Graphs Biological Systems
10 min	Station 2	GROUP WORK
10 min	Station 3	GROUP WORK
10 min	Station 4	GROUP WORK

4 min	Closure Question: What do you think will be the easiest consequence to deal with? What do you think will be the most difficult consequence to adapt to as an individual? As a society?	DISCUSSION
HW	Based on what we've learned so far, what are some ways that climate change might affect the community where you live?	
Day 3		
2 min	BW: List one way that climate change impacts a) agriculture b) ecosystems and c) weather and d) health and disease	INDIVIDUAL SEATWORK
10 min	Differences between mitigation and adapation - Review definition - Students discuss in pairs - Fill in KWL chart	GROUP DISCUSSION See 5.3.1 Adaptation Resources See 5.3.2 Mitigation and Adaptation Slides
15 min	The Great Discussion Prep: Students will work in groups, pulling together the various activities, data, and information they have learned over the course of the Climate Change Unit. Due to resources only ONE area of impact can be addressed. You will be assigned one of the four topics from the stations. Why should your topic be the one area addressed? Give examples and evidence to support your position. (including feasible and practical mitigations and adaptations)	GROUP WORK Teacher will assign each group an area of impact: ecosystem, agriculture, severe weather, or health.
25 min	The Great Discussion Presentations	STUDENT GROUP PRESENTATION Discussion format: teacher's choice

Lesson Plan 5 - Consequences of Climate Change & Adaptation

5.0 List of Resources

5.1.1 Consequences Slides
5.1.2 LP4 Quiz & Key
5.1.3 Sea Level Activity Instructions and Datasheet

5.2.1 Sample Evidence Claim
5.2.2 Station Task Cards
5.2.3 Student Questions
5.2.4 Station Graphs Biological Systems

5.3.1 Adaptation Resources

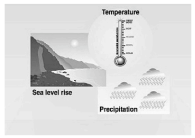
7.1.4 Wedge Strategies Table

Consequences of Climate Change: Sea Level Rise

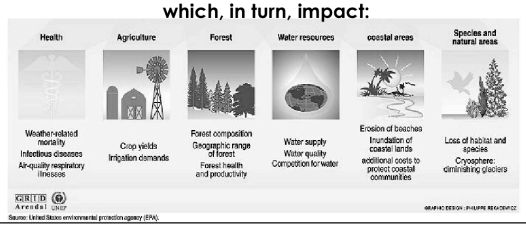
Albedo
Positive Feedback Loop

- ✓ different surfaces have different level of reflectivity
- ✓ Ice reflects more light than other substances
- ✓ Snow reflects 95% of radiation
- ✓ The water under the ice can absorb large amounts of heat energy, which could increase temp of water and cause more melting

Climate changes impact:



which, in turn, impact:

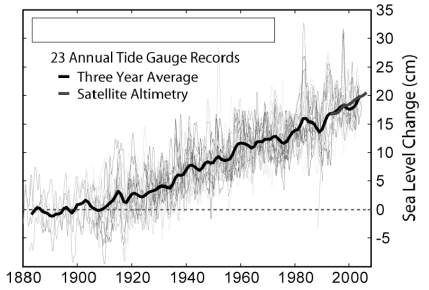


Source: United States environmental protection agency (EPA).

SEA LEVEL RISE

Recent Sea Level Rise

tidal and satellite records from 1880 to 2005



http://www.globalwarmingart.com/wiki/Image:Recent_Sea_Level_Rise.png

IMPACTS ON COASTAL AREAS

Sea-level rise

Heavily populated delta regions that are vulnerable to sea level rise

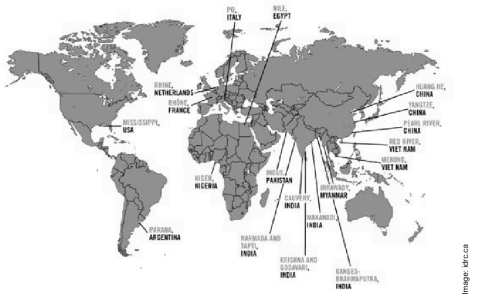


Image: IDRC.ca

If you have an internet connection, go to the following websites at this point and explore how rising sea levels would affect different regions of the globe. If time permits and students have access to computers, you may wish to let students explore this site in pairs or small groups. The following regions are particularly vivid examples of the impacts of sea-level rise on heavily populated coastal regions. More than 100,000,000 people live in these regions. Encourage students to think about the effects of such massive number of refugees from these major metropolises.

San Francisco Bay Area: http://flood.firetree.net/?ll=38.0308,-122.4426&z=8&m=0&t=1

Manhattan: http://flood.firetree.net/?ll=40.7551,-74.0293&z=6&m=0&t=1

Florida: http://flood.firetree.net/?ll=28.0914,-82.2876&z=10&m=0&t=1

The Netherlands: http://flood.firetree.net/?ll=52.2278,5.8447&z=10&m=0&t=1

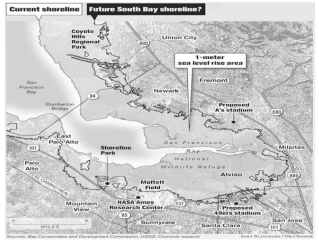
Beijing: http://flood.firetree.net/?ll=38.5310,116.8781&z=10&m=0&t=1

Shanghai: http://flood.firetree.net/?ll=32.8704,119.5642&z=10&m=0&t=1

Calcutta & Bangladesh: http://flood.firetree.net/?ll=22.9786,89.3793&z=9&m=0&t=1

What about the Bay Area?

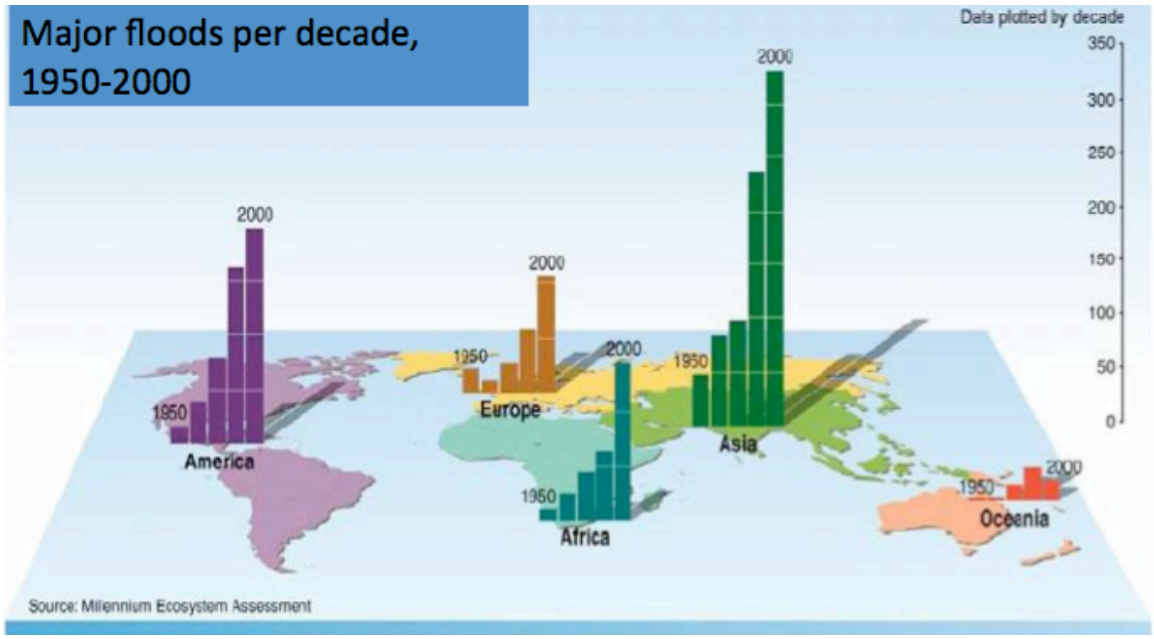
- ✓ **Sea level rise is an important consequence in coastal areas like the Bay Area**



Student Name _____

5.1.3 Lesson Plan 4 Quiz

Use the graph below to answer questions 1-3.



1. What is the global trend of major floods since 1950?

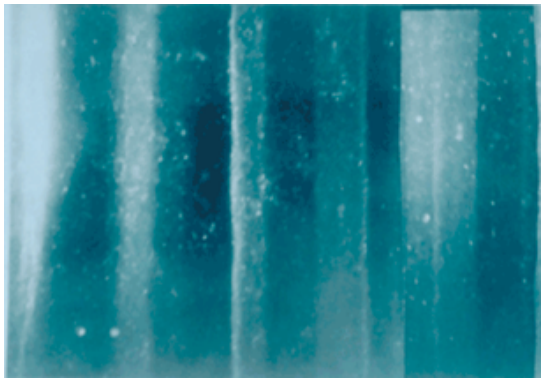
2. Provide two pieces of evidence that support this claim.

3. How do scientists determine climate conditions from 100,000 years ago?

   A. Thermometer Readings
   B. Satellite Images
   C. Tree Rings
   D. Ice Cores

4. About how many years does this ice core sample represent?

A. 1-2 years
B. 4-5 years
C. 15-16 years
D. 25-26 years



5. Provide two examples for how people can mitigate climate change through transport conservation.

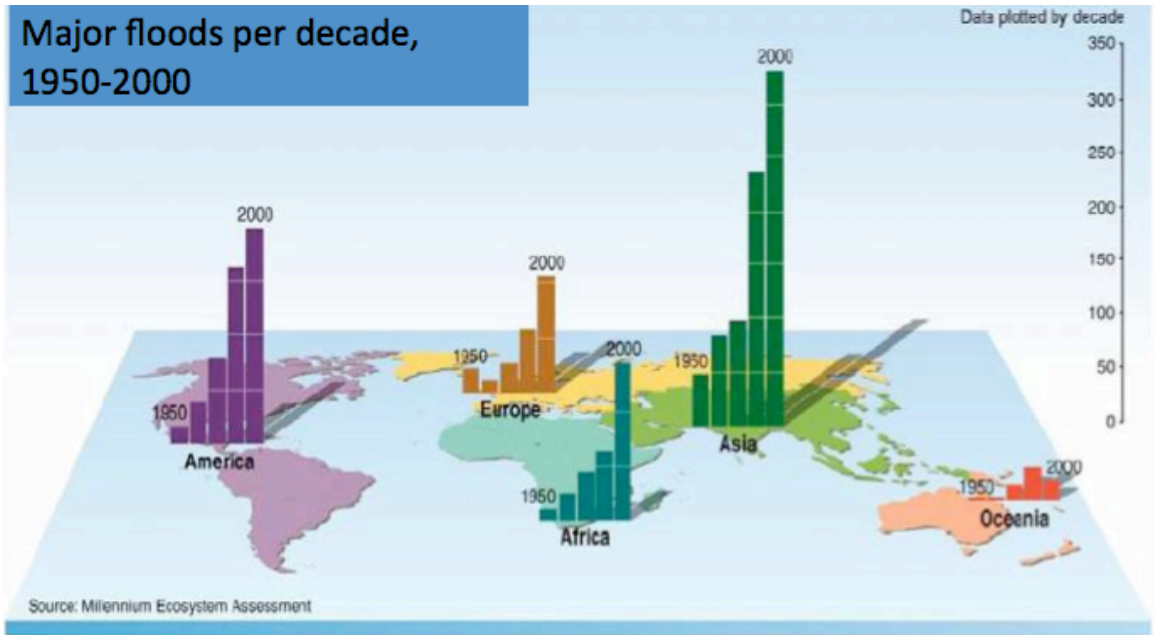
1.

2.

6. Why does insulating buildings help mitigate climate change?

Student Name ____Key_____
Lesson Plan 4 Quiz

Use the graph below to answer questions 1-3.



1. What is the global trend of major floods since 1950?

Major flooding has increased on every continent since 1950.

2. Provide two pieces of evidence that support this claim?

Flooding in America has increased steadily from about 10 floods in 1950 to over 200 floods in 2000.

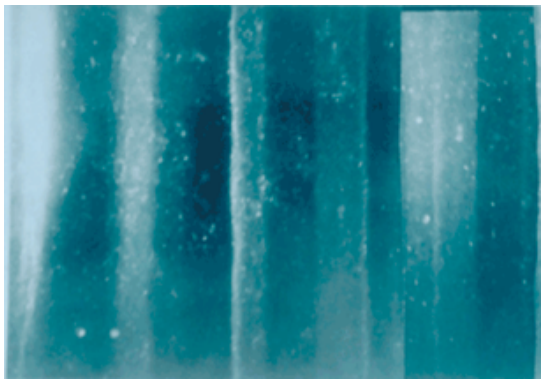
Flooding in Africa has increased steadily from about ten floods in 1950 to about 100 floods in 2000.

3. How do scientists determine climate conditions from 100,000 years ago?

A. Thermometer Readings
B. Satellite Images
C. Tree Rings
D. Ice Cores

4. About how many years does this ice core sample represent?

A. 1-2 years
B. 4-5 years
C. 15-16 years
D. 25-26 years



5. Provide two examples for how people can mitigate climate change through transport conservation.

1. Take public transportation

2. Walk or ride a bicycle to nearby locations

6. Why does insulating buildings help mitigate climate change?

Insulating a building prevents heat from escaping. This means that heating systems use less electricity. Since the electricity comes mostly from coal-powered power plants, the decrease in electricity will decrease the amount of carbon emissions.

5.1.3

Sea Level Rise Investigation: Sea Ice and Land Ice Melting

MATERIALS
Two 2-Liter Beakers
Two 250-mL (milliliter) Beakers
Crushed Ice
Saran Wrap
Sand
Water
Graduated Cylinder or beaker for measuring out 600 mL of water
Ruler

METHOD
1. Label the one 2L beaker “Sea Ice” and a second 2L beaker “Land Ice”
2. Fill each of the 250 mL beakers with equal amount of sand
3. Cover each sand filled beaker with saran wrap. Tape the bottom of the saran wrap to secure in place.
4. Place a sand filled beaker in each 2L beaker
5. Next, pour 600 mL of water in each of the 2L beakers
6. Measure and record this original level (depth) of water in each beaker and record on table
5. In “Sea Ice” beaker, add crushed ice cubes to the water around the 250 mL beaker. This represents Floating (Sea) Ice
6. In “Land Ice” beaker, place the same amount of crushed ice on top of the saran wrap. This represents Land Ice
7. Place both 2L beakers outside or under a lamp
8. Check the water level and ice every ten minutes throughout the session and record your observations on the data table

http://users.skynet.be/deneyer/

DATA TABLE

	Sea Ice (Iceberg) BEAKER 1		Land Ice (Antarctica) BEAKER 2	
Time	Water Level	Remaining Ice	Water Level	Remaining Ice
0 min				
10 min				
20 min				
30 min				

Discussion Questions:

1. What happened? Did the water level in either bowl change as the ice melted?

2. What is different between the two conditions?

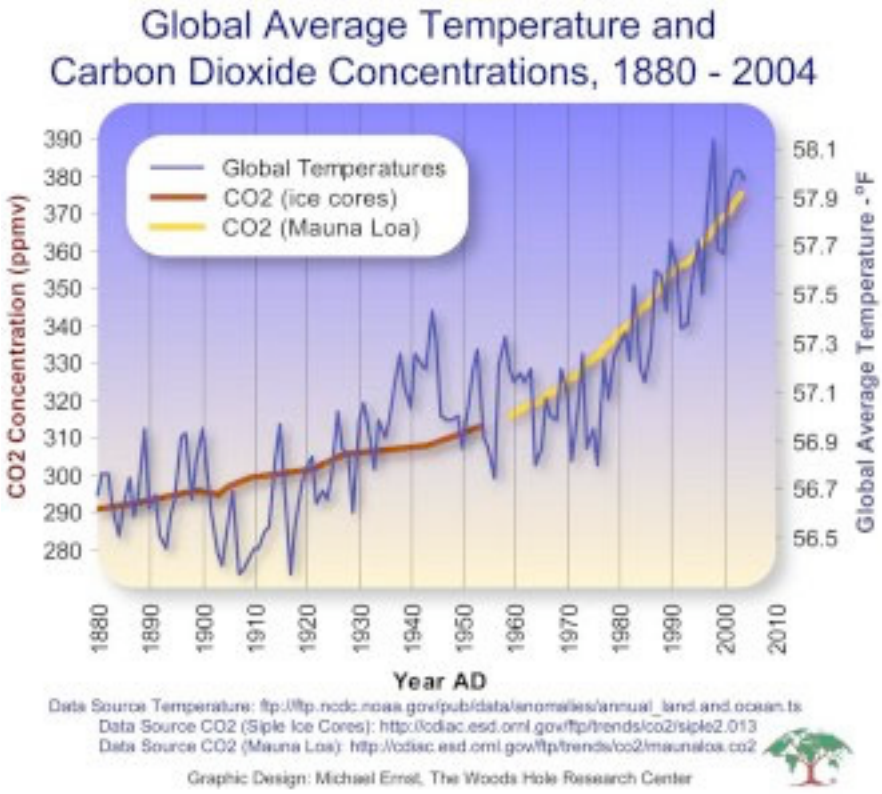
3. How does climate change impact the melting of ice?

4. Which type of ice would impact sea level?

5. During ice ages when the Earth was much colder, do you think sea level was higher or lower than current sea level?

How do we use evidence to support claims?

Here's an example of using data and a graph as evidence.



Using the graph above, what claims can be made about global average temperature and carbon dioxide concentrations over time? Use Evidence to support your claims.

Claim #1: When there are higher concentrations of CO_2 in the air, the temperature is also higher.

Evidence to support the claim: The graph shows that from 1880 to 2010, the amount of CO_2 has gone up, and so has the global average temperature.

Claim #2: The global temperature is rising at a more rapid rate because of human activity.

Evidence to support the claim:
Over the 80 years from 1880 to 1950 the amount of CO_2 increased from by 20 ppm and the temperature increased 0.4 degrees.

Over the 20 years from 1960 to 2010 the amount of CO_2 in the increased by 60 ppm and the temperature increased by 1.0 degrees.

Station 1 Task Card
Ecosystems

Evidence for the Impact of Climate Change on the Biological System

Materials

- Task Card
- Station Questions, p.1
- Graph 1

Instructions

1. As a group, look at graphs 1. Talk about what you think it represents prior to looking at the questions for this station.

2. Feel free to ask each other questions about parts of the graph that you don't understand or point out parts of the graph that you think are important. It is helpful to start by identifying what each axis represents.

3. After looking at the graphs, read the questions for this station that appear below. Discuss each question as a group.

4. After you are finished discussing the questions, individually answer the two questions for each station on the student handout.

Graph 1

1. What do the numbers across the bottom of this graph represent?

2. Which ecosystem will be most impacted even at a low increase in temperature?

3. Which ecosystems are the least impacted at lower temperature change?

(Now make an evidence supported claim on your student handout)

Station 2 Task Card
Agriculture

Evidence for the Impact of Climate Change on the Biological System

Materials

- Task Card
- Station Questions, p.2
- Graph 2
- Graph 3

Instructions

1. As a group, look at graphs 2 & 3. Talk about what you think they represent prior to looking at the questions for this station.

2. Feel free to ask each other questions about parts of the graph that you don't understand or point out parts of the graph that you think are important. It is helpful to start by identifying what each axis represents.

3. After looking at the graphs, read the questions for this station that appear below. Discuss each question as a group.

4. After you are finished discussing the questions, individually answer the two questions for each station on the student handout.

Graph 2:

1. What is this graph predicting?

2. What is the impact of climate change on countries with lower percentages?

3. Based on this image, what are some countries and/or continents that will be most negatively impacted?

4. How might humans be impacted by decreased agricultural productivity?

Graph 3 :

5. As temperature increases, what happens to the amount of corn and rice produced?

6. What is meant by a "positive change in precipitation"? How would you expect more precipitation to impact crop yield?

(Now make an evidence supported claim on your student handout)

Station 3 Task Card
Severe Weather Events

Evidence for the Impact of Climate Change on the Biological System

Materials

- Task Card
- Station Questions, p.3
- Graph 4

Instructions

1. As a group, look at graphs 4. Talk about what you think it represents prior to looking at the questions for this station.

2. Feel free to ask each other questions about parts of the graph that you don't understand or point out parts of the graph that you think are important. It is helpful to start by identifying what each axis represents.

3. After looking at the graph, read the questions for this station that appear below. Discuss each question as a group.

4. After you are finished discussing the questions, individually answer the two questions for each station on the student handout.

Graph 4

4. What is this graph representing? What is the overall trend?

5. What might be the connection between climate change and increasing forest fires?

(Now make an evidence supported claim on your student handout)

Station 4 Task Card
Human Health

Evidence for the Impact of Climate Change on the Biological System

Materials

- Task Card
- Station Questions, p.4
- Graph 5
- Diagram 6

Instructions

1. As a group, look at graphs 6 & 7. Talk about what you think they represent prior to looking at the questions for this station.

2. Feel free to ask each other questions about parts of the graph that you don't understand or point out parts of the graph that you think are important. It is helpful to start by identifying what each axis represents.

3. After looking at the graphs, read the questions for this station that appear below. Discuss each question as a group.

4. After you are finished discussing the questions, individually answer the two questions for each station on the student handout.

Graph 5

1. What does "mortality per million population" mean?

2. What regions of the globe have the highest mortality rate due to global warming? Why might this be?

3. What are some ways that climate change might impact mortality?

Diagram 6

5. What does this graphic show?

(Now make an evidence supported claim on your student handout)

Name _____

Student Handout 5.2.3
Evidence for the Impact of Climate Change on Biological Systems

Overall Conclusions

1. Based on graphs 1 what claim (conclusion) can you make about the effects of climate change on ecosystems?

2. What evidence supports your claim?

ADAPTATIONS: Animal and tree species migrating to a more suitable climate is one adaptation. However, there are challenges and obstacles for some species (for example, corals can only live in shallow water) in various ecosystems that make migration difficult if not impossible. Some species may not be able to adapt.

Name _____

Student Handout 5.2.3
Evidence for the Impact of Climate Change on Biological Systems

KEY TERMS:

Agricultural productivity: this refers to the level of crops (food) being produced. A high level of productivity means a high level of crops being produced.

Projected changes: Using computer models, changes in agriculture in 70 years from now can be estimated.

Precipitation: rain, sleet, hail or snow; any water that falls from the sky

Overall Conclusions

1. Based on graphs 2 & 3, what claim (conclusion) can you make about the effects of climate change on agriculture?

2. What evidence supports your claim?

ADAPTIONS: Planting different crops that can withstand the impact of climate change, breeding new plant species that are more tolerant to the changing conditions, changing the times of the year when crops are planted, controlling insects

Name _____

Student Handout 5.2.3
Evidence for the Impact of Climate Change on Biological Systems

Overall Conclusions

1. Based on graph 4, what claim (conclusion) can you make about the effects of climate change on wild lands?

2. What evidence supports your claim?

ADAPTATIONS: Protecting the shore (building dikes and other structures) from flooding, protect water supplies from contamination by salt water, improving early warning systems in the event of possible flooding, promoting and improving fire suppression practices (putting out fires)

Name_____

Student Handout 5.2.3
Evidence for the Impact of Climate Change on Biological Systems

Key Terms:

Mortality: refers to death; a high mortality rate means a high number of deaths

Pollen: During the spring, summer, and fall, plants release pollen (a fine powder that is carried by the wind from plant to plant in order to fertilize them). Breathing in pollen can cause an allergic reaction, like coughing and sneezing.

Overall Conclusions

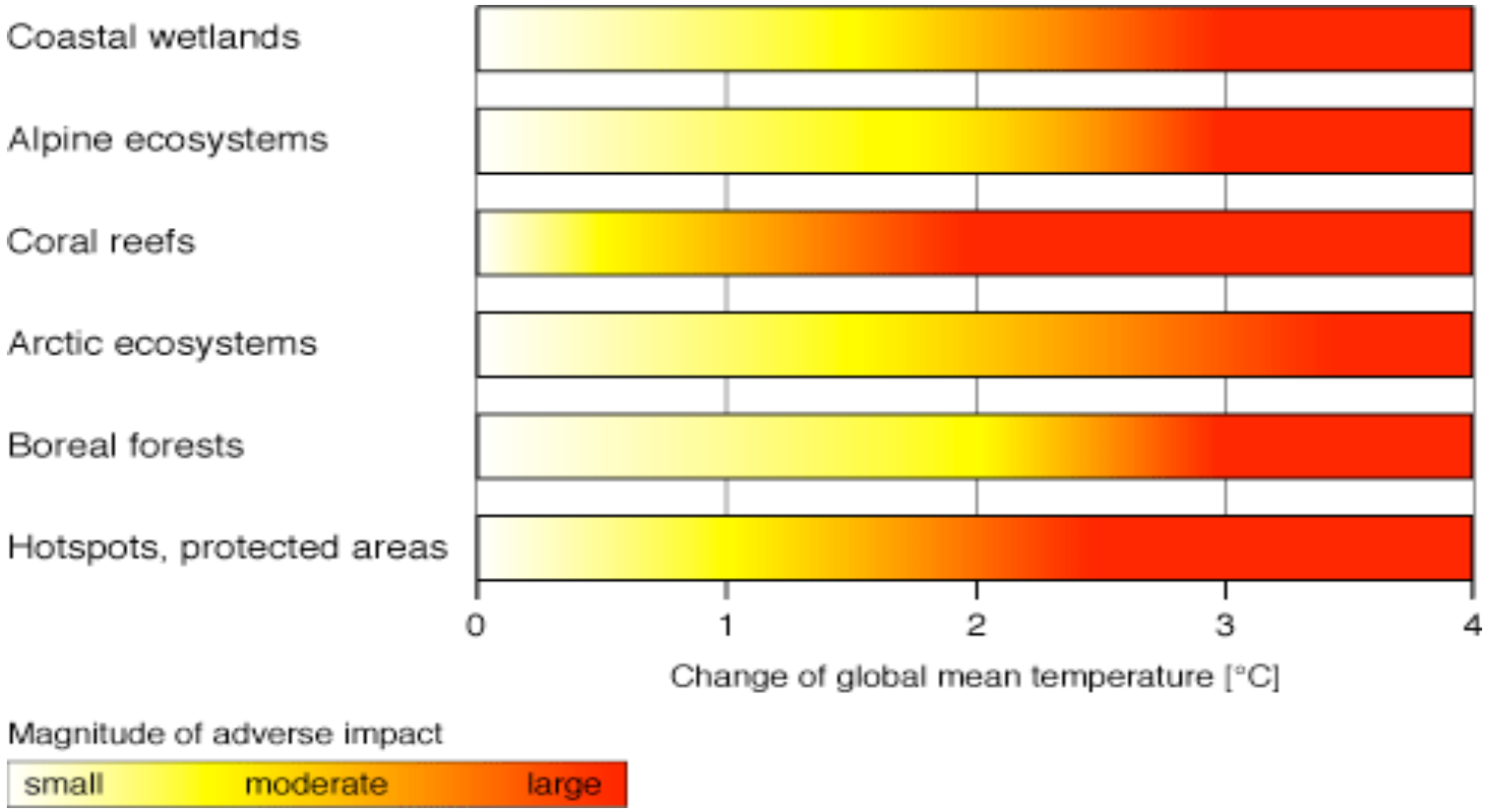
1. Based on the graph 5 and diagram 6, what claim can you make about the effects of climate change on human health?

2. What evidence supports your claim?

ADAPTATIONS: Planting trees in cities to moderate the temperature, news and weather advisories to warn the people about dangerous heat conditions, adjusting clothing to handle the temperature, monitoring (and if necessary reducing) activity levels to avoid exhaustion, increasing water intake, programs to give information about prevention and control of diseases

Climate Change in Biological Systems

Graph 1: Impact of Climate Change on Natural Ecosystems



Coastal Wetland: low lying, marsh, swamp **Alpine**: cold mountaintops
Coral Reefs: ridge of coral near water (marine) **Arctic**: near north pole
Boreal Forests: northern forests (sub-arctic) **Hotspots:** rain forests
Image from: http://www.wbgu.de/wbgu_sn2003_voll_engl.html

Graph 2: Predicted Impact of Climate Change on Agricultural Productivity

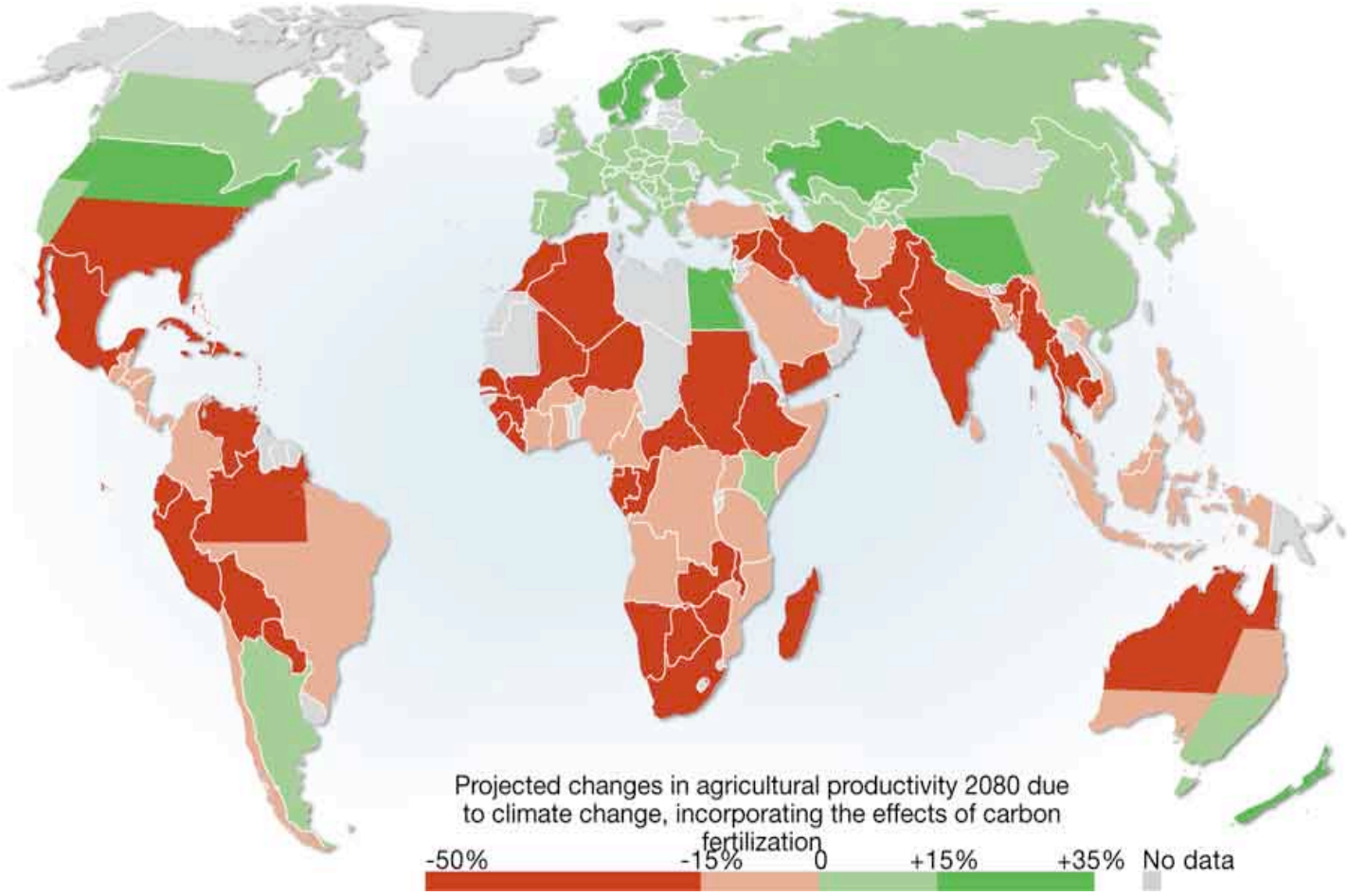


Image: http://www.wri.org/stories/2008/09/climate-change-brings-new-urgency-millennium-development-goals

Graph 3: Impact of Climate Change on Crop Yield (Food Production)

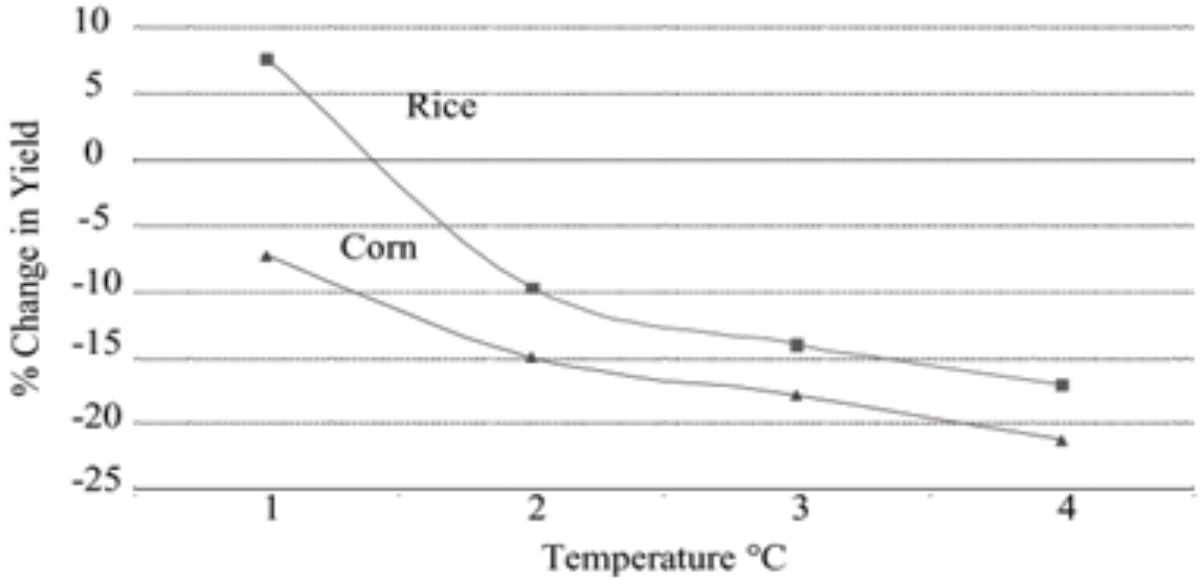
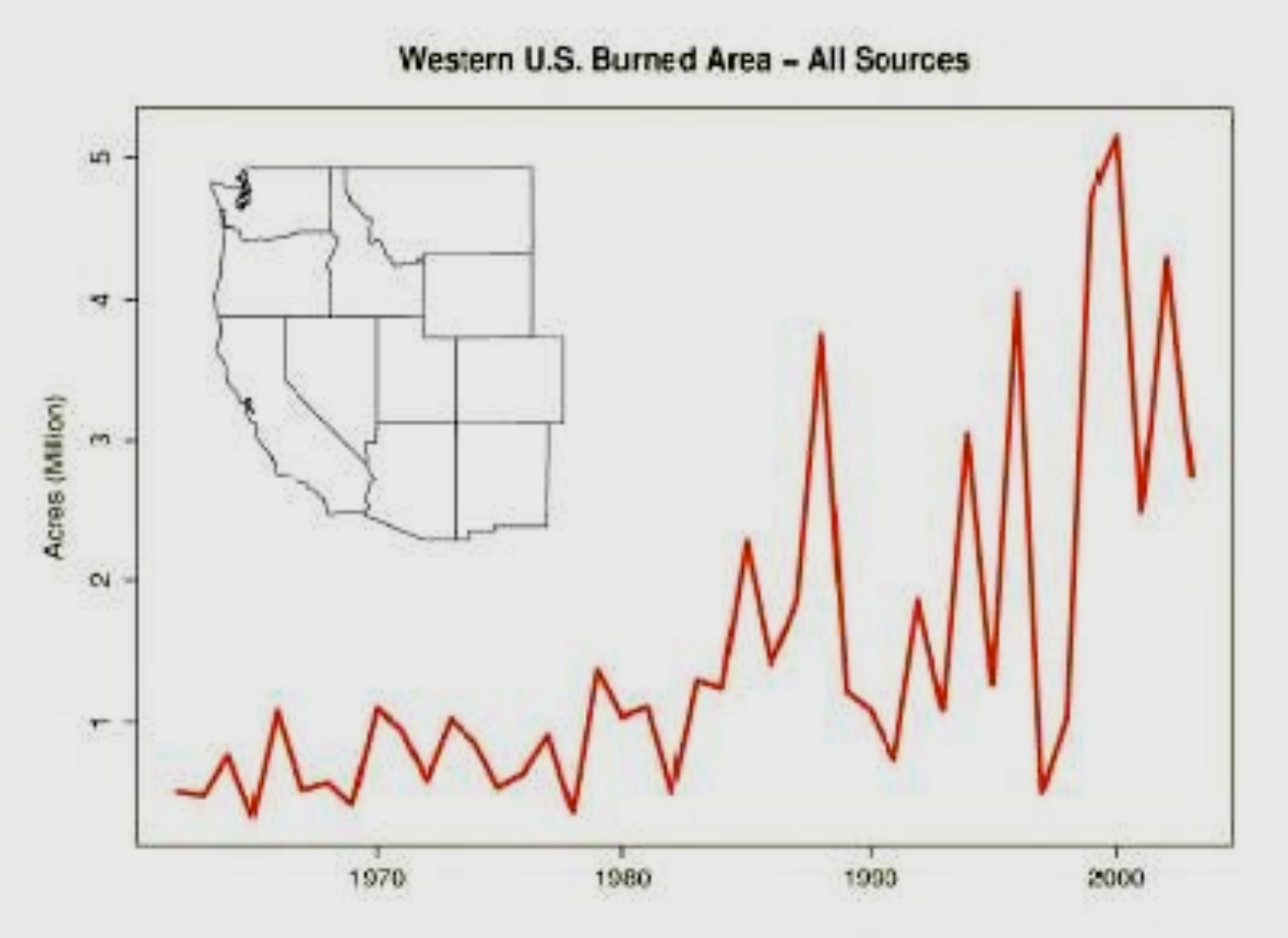


Figure 2 - Corn and rice yields versus temperature increase in the tropics averaged across 13 crop modeling studies. All studies assumed a positive change in precipitation. CO_2 direct effects were included in all studies. Adapted form Easterling & Apps (2005).

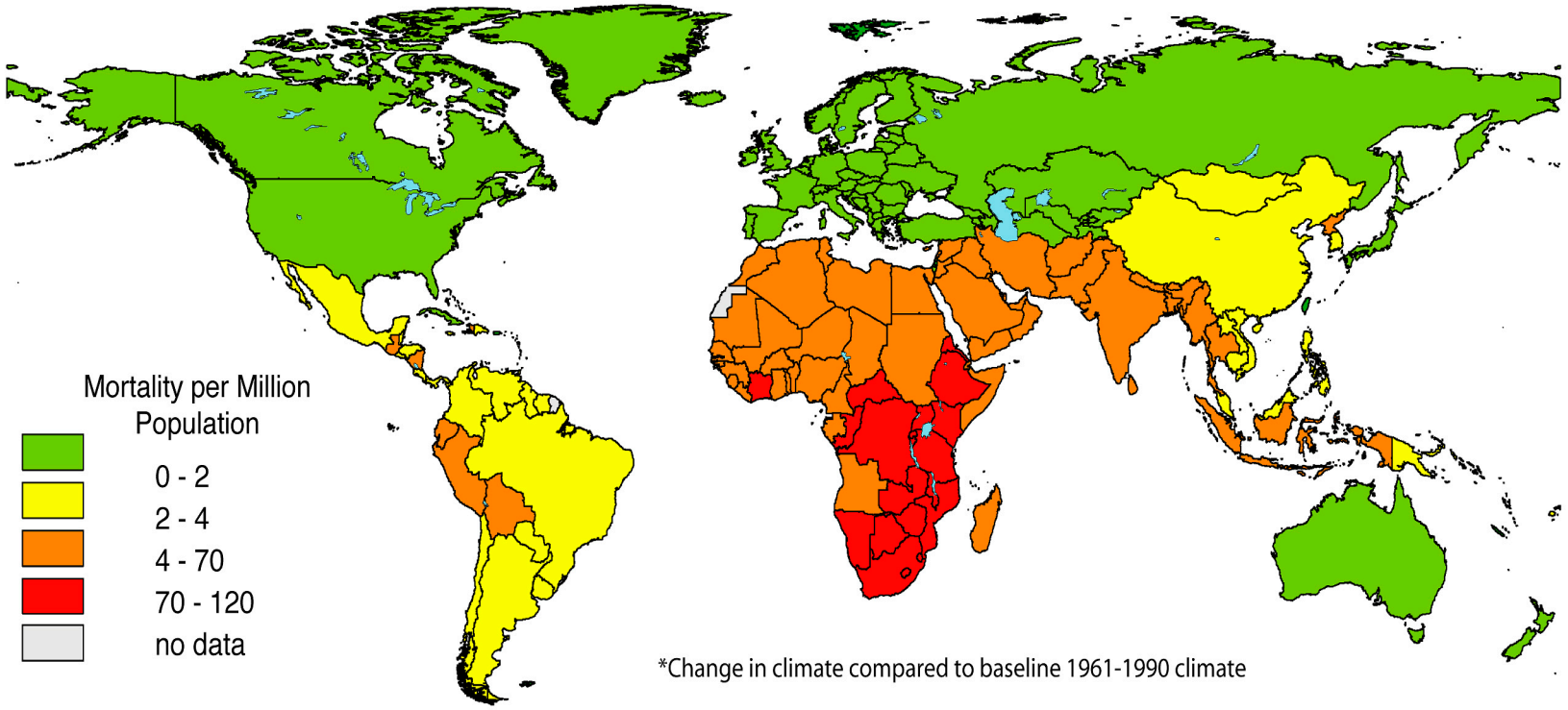
Image: http://www.scielo.br/img/revistas/sa/v64n1/a13fig02.gif

Graph 4: Fire on Wildland



Graph 5: Impact of Climate Change on Mortality

Estimated Deaths Attributed to Climate Change in the Year 2000, by Subregion*

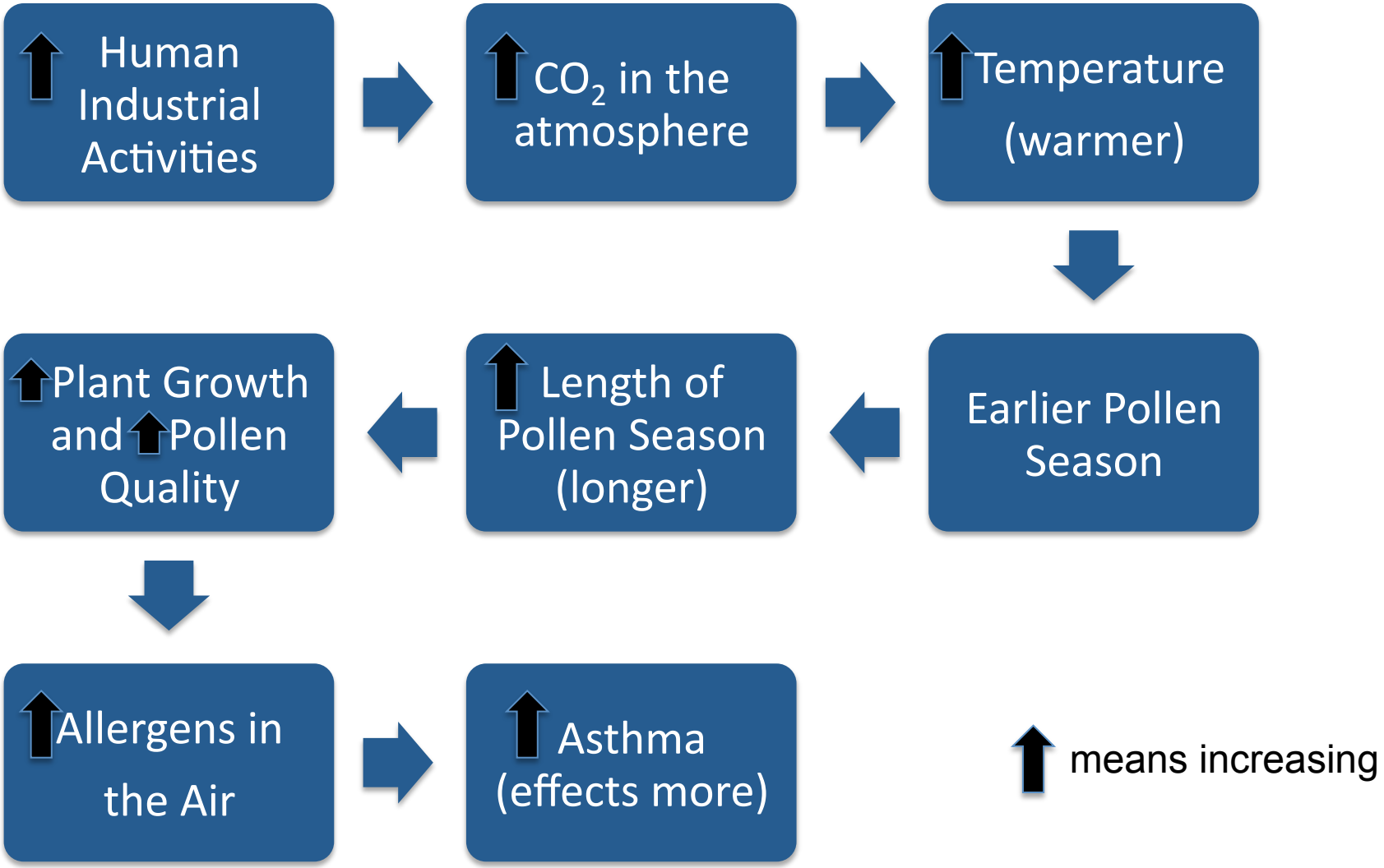


Data Source:
McMichael, JJ, Campbell-Lendrum D, Kovats RS, et al. Global Climate Change. In Comparative Quantification of Health Risks: Global and Regional Burden of Disease due to Selected Major Risk Factors. M. Ezzati, Lopez, AD, Rodgers A., Murray CJL. Geneva, World Health Organization, 2004

sage

Maps produced by the Center for Sustainability and the Global Environment (SAGE)

Diagram 6: Impact of Climate Change on Asthma



4.4.2
Teacher/Student Resources

Climate Change Adaptation Strategies

Ecosystems: Animal and tree species migrating to a more suitable climate is one form of adaptation. However, there are challenges and obstacles for some species (for example, corals can only live in shallow water) in various ecosystems that make migration difficult if not impossible. Some species may not be able to adapt.

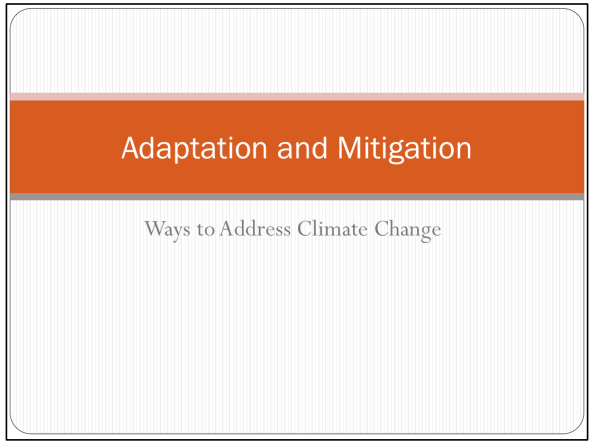
Agriculture: Planting different crops that can withstand the impacts of climate change, breeding new plant species that are more tolerant to the changing conditions, changing the times of the year when crops are planted, controlling insects

Extreme Weather: Protecting the shore (building dikes and other structures) from flooding, protecting water supplies from contamination by salt water, improving early warning systems in the event of possible flooding, promoting and improving fire suppression practices (putting out fires)

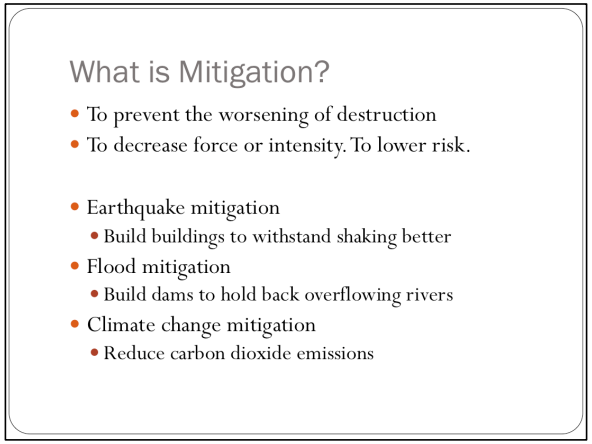
Human Health: Planting trees in cities to moderate the temperature, news and weather advisories to warn people about dangerous heat conditions, adjusting clothing to handle the temperature, monitoring (and if necessary reducing) activity levels to avoid exhaustion, increasing water intake, programs to give information about prevention and control of diseases

California Sectors Sensitive to Climate Change

Sector	*Example Climate Impacts*	*Example Adaptation Actions* **Short-Term**	*Example Adaptation Actions* **Long-Term**
Public Health	Decreased air quality	Strictly enforce existing air quality standards and educate public on connections between air quality and climate change.	Implement ongoing monitoring to identify hotspots of vulnerability and enable flexible responses to surprises.
Water Supply	Reduced Sierra snowpack and earlier annual melting; Less reliable water supply; Increased water demand	Implement water conservation programs, expand conjunctive use, and support infrastructure investments for storm-water and wastewater recovery.	Increase flexibility of water transfer mechanisms and improve groundwater basin management.
Agriculture	Increasing threats to agricultural production due to less reliable water supply and increases in high temperature extremes	Increase water use efficiency for irrigation and enhance access to localized climate information,	Expand research, development, and deployment of heat and drought-tolerant crops.
Marine/ Coastal	Inundation of coastal areas and increased coastal storm impacts and erosion	Assess the vulnerabilities of existing and planned coastal infrastructure and support enhanced disaster response planning including coastal armoring to protect critical infrastructure and softer strategies that preserve habitats and beaches.	Modify planning and zoning processes to reduce development in areas most vulnerable to sea level rise.
Ecosystems	Loss of habitat, biodiversity; species extinction	Reduce existing non-climatic pressures on ecosystems – such as habitat fragmentation and pollution. Prioritize development of natural reserves containing a range climate conditions and habitat types.	Expand monitoring of networked protected areas to support species migration and adaptive responses to change.
Forestry	Increased wildfire risk; increased pest outbreaks	Decrease non-climatic pressures on forests such as air pollution. Use fire-resistant building materials in vulnerable areas.	Modify planning and zoning processes to reduce development in fire-prone areas. Monitor to understand trends in vulnerability.
Energy	Increased electricity demand	Strengthen energy efficiency in building codes and implement pricing schemes to reduce peak electricity demand.	Enhance capacity to meet peak demand through renewable energy sources.



Adaptation and mitigation are complementary strategies that are both required to address climate change. In the past, adaptation was a bit of a taboo in environmental circles, the rationale being that talk of other policies would lessen the focus on mitigation. Now there is general recognition that we need both.



Some official definitions of mitigation: To moderate in force or intensity, to alleviate. To lessen in force or intensity. Elimination or reduction in frequency, magnitude or severity of exposure. To minimize risk.

An informal definition that could be used to discuss the idea: Basically to make something that could be very bad less bad.

Ask for examples of things people do to "mitigate" for the following environmental effects:

Earthquake – build houses to building codes, try to get people to have emergency kits, meeting points.
Floods – build houses on stilts, make walls so the water can't get in. Create dams.
Climate Change – mostly involve decreasing the amount of greenhouse gases of all kinds in the atmosphere. For the most part, mitigation cannot reverse warming that has already occurred, it can only slow or stop what would come without any changes.

What is Adaptation?

- Reacting or changing to fit the new circumstance
- Coping with impacts that cannot be avoided

Examples:

- farmers planting different crops for different seasons
- wildlife migrating to more suitable habitats as the seasons change.
- Building levees against sea level rise

Some official definitions of mitigation: To moderate in force or intensity, to alleviate. To lessen in force or intensity. Elimination or reduction in frequency, magnitude or severity of exposure. To minimize risk.

An informal definition that could be used to discuss the idea: Basically to make something that could be very bad less bad.

Ask for examples of things people do to "mitigate" for the following environmental effects:

Earthquake – build houses to building codes, try to get people to have emergency kits, meeting points.
Floods – build houses on stilts, make walls so the water can't get in. Create dams.
Climate Change – mostly involve decreasing the amount of greenhouse gases of all kinds in the atmosphere. For the most part, mitigation cannot reverse warming that has already occurred, it can only slow or stop what would come without any changes.

A clever colleague once said

"Mitigation helps us avoid the unmanageable, while adaptation helps us manage the unavoidable."

There are still some aspects of mitigation and adaptation that will require tradeoffs or generate synergies. For example, an adaptation strategy to deal with more heat waves could be wider adoption of air conditioning, leading to increased energy usage and higher greenhouse gas emissions (if the electricity is generated using fossil fuels). On the other hand, greater adoption of drought-tolerant crops could reduce agricultural water usage and associated pumping of water which also could reduce energy usage.

There is also the possibility of "maladaptation." For example, building better levees can encourage more development in flood plains and even worse damages if/when those levees are compromised.