Chapter 8

Introduction to Energy: Sources and Kinds

- Energy within the Earth
- Energy from the Sun

The energetic basis of life

Energy use by people: renewable energy and non-renewable energy

Agricultural land issues

Global Environmental Challenges

- Climate change
- Ozone depletion
- Dead zones, fertilizers and manure management
- Population
- Solid waste
- Air quality

Introduction to Energy: Sources and Kinds

Energy exists in a variety of forms

- mechanical

- thermal

- electrical

- chemical

Energy can be converted from one form to the other

Potential and Kinetic Energy

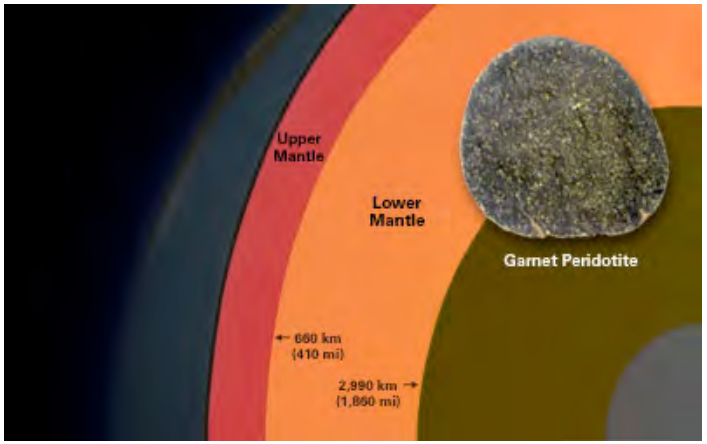
Ex. Dropping a ball from shoulder height

- at shoulder height, the ball is full of potential energy
- when you drop it, the potential energy gets converted to kinetic energy
- the ball's speed increases as its potential energy is completely transformed to kinetic energy

- once the ball hits the floor, some of its kinetic energy is converted to electromagnetic energy
  - sound
  - light
  - heat
- most of its kinetic energy is transformed to elastic potential energy
  - used to power the rise of the ball back to your hand
  - it will never return to its original height however

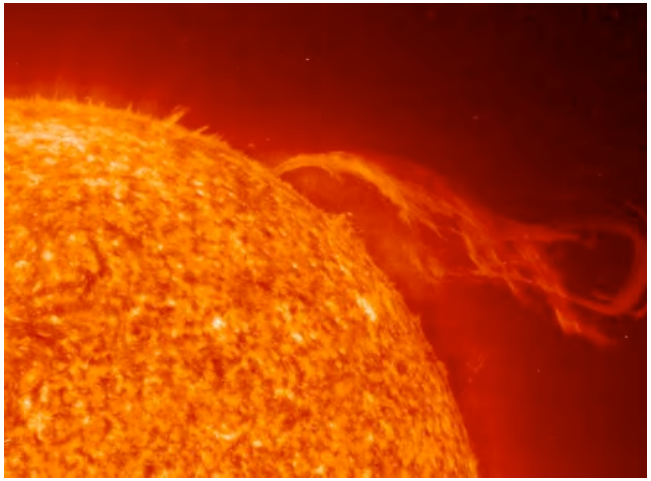
Sources of Energy

a. energy from within the Earth
   - primordial heat
     - earth was formed 4.6 billion years ago by bits of rock and dust coalescing
       - ➢ each bit of rock contained certain amount of energy



- ➢ as rocks coalesced, some of the energy was trapped
- ➢ this energy melted superior layers of rock to form mantle

b. energy from the sun
   - giant ball of gasses undergoing continuous fusion reactions
   - releases electromagnetic energy
   - captured by photosynthetic organisms on Earth

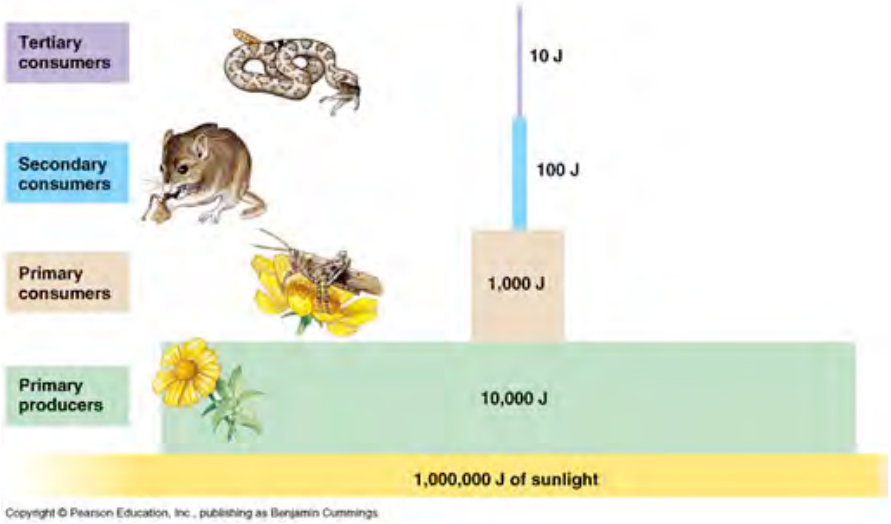


The Energetic Basis of Life

Sun's energy is used mainly in two ways

a. changing water from solid to liquid form to gas form
   - drives climate

b. transformation into energy of chemical bonds in green plants
   - provides food for all other life forms



c. energy transformations in biological systems are inefficient
   - only 10% of energy passes up the next level of the food chain
   - its most energetically efficient when people eat grains, vegetables and fruits

Energy use by people

Two most common types of energy usage

a. electricity: the flow of electrons
   - often generated using a turbine

b. gasoline
   - burned and converted to mechanical energy

90% of energy that people use is generated from burning fossil fuels

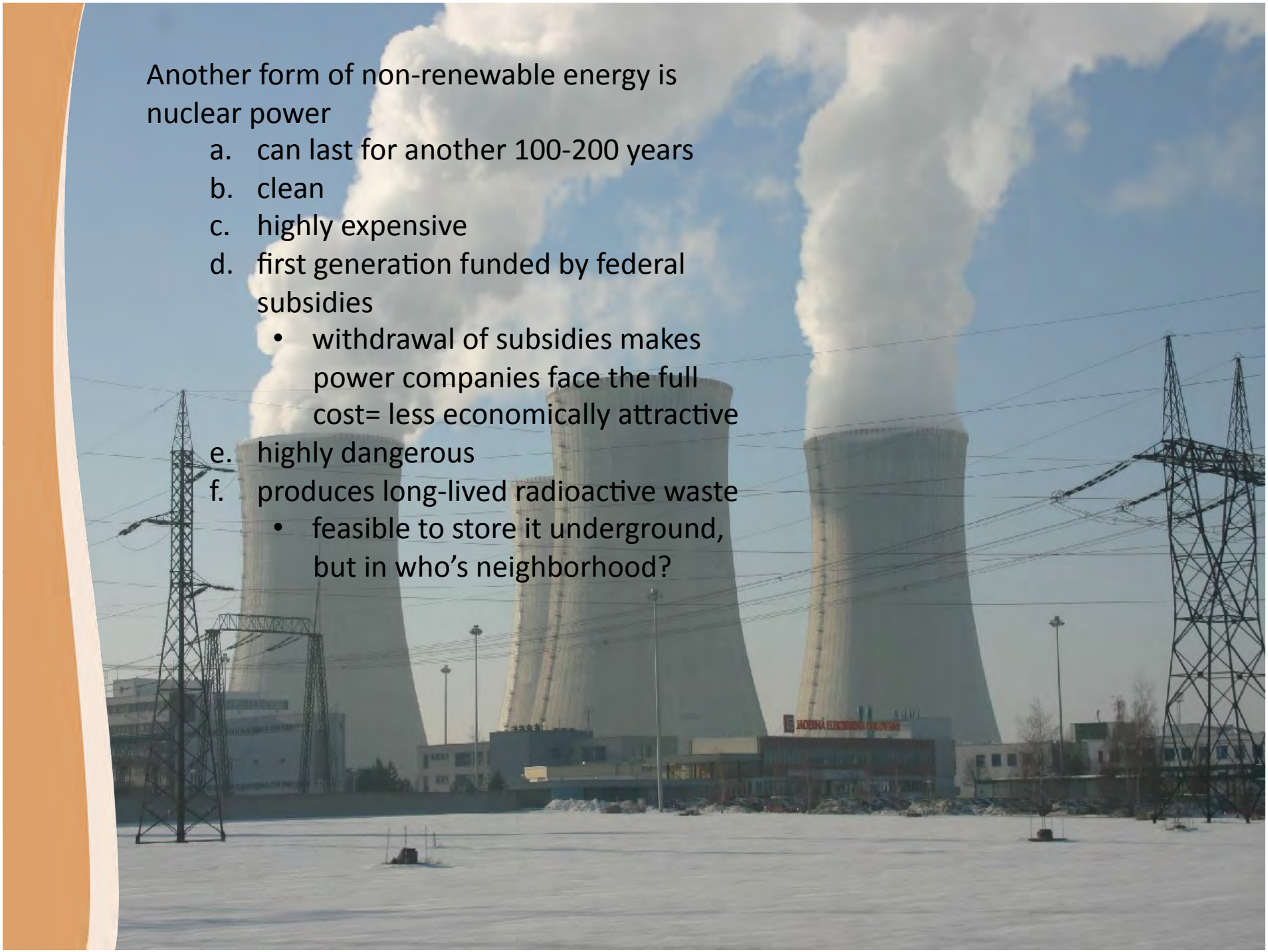
- fossils fuels: carbon rich compounds formed by ancient plants
- inexpensive to obtain, cheap to transport or store
- technology to transform fossil fuels to useable energy is simple, well developed and safe
- NOT RENEWABLE
- petroleum and natural gas will be depleted within 100 years
- coal will be depleted in 400 years
- undesirable byproducts
  - CO_2 production

Three forms of fossil fuels

a. oil
   - procured by drilling and pumping
   - used to make gasoline, diesel

b. coal
   - extracted from Earth using digging, mining techniques and heavy machinery
   - dirty energy source
   - CA imports electricity from coal-powered power plants in Utah and Wyoming
     - outsourcing our air pollution?

c. natural gas
   - cleanest of the three
   - used to power CA power plants (CA has no coal fired power plants)
   - 40% of our electricity
     - inefficient usage of natural resource
     - more efficient to directly use it to heat homes



Another form of non-renewable energy is nuclear power

a. can last for another 100-200 years
b. clean
c. highly expensive
d. first generation funded by federal subsidies
   - withdrawal of subsidies makes power companies face the full cost= less economically attractive
e. highly dangerous
f. produces long-lived radioactive waste
   - feasible to store it underground, but in who's neighborhood?

Geothermal energy straddles border between renewable and non-renewable energy

a. virtually inexhaustible
b. portion accessible from surface area often distant from major metropolitan areas
c. technology used to transform the geothermal heat to electricity can sometimes behave like non-renewable energy
d. potential locations often located in our most pristine park lands

Clean, renewable energy

a. solar
   - huge potential for small scale and industrial production
   - currently expensive compared to fossil fuels, although that is in part due to oil subsidies
   - cost structure for solar power will change as technology improves and growing demands facilities mass production

b. wind power
   - captures wind energy via large arrays of windmills
   - captured energy used to drive a turbine
   - main limitation is the lack of many places that have sufficient windy conditions
   - wind farms run into local opposition
   - aesthetic objections
     - opposition from bird lovers who fear for safety of birds

c. hydroelectric energy
   - captures mechanical energy of falling water via dams and turbines
     - dark side is that it requires damming rivers, which can dramatically alter river ecology
       - ➢ caused the Pacific salmon crisis

d. ocean wave/tidal wave power
   - wave power is captured by buoys anchored to the sea floor
   - tidal power is captured in estuaries
   - uses dams that allow the tide to raise the water level, then run the outflow through turbines to generate electricity

e. biofuels for powering vehicles
   - ethanol and alcohol are energy rich fuels
     - produced from various plant products
     - technology is still being perfected
     - most cars in Brazil run on 85/15 blend of alcohol to gasoline

- What plants will be the sources?
  - sugar cane is the easiest to use technically
  - requires prime agricultural land to grow which could have been used to grow food
  - input energy to make grow sugar cane < output energy
  - corn on the other hand represents a net overall loss of usable energy
  - it is only subsidies to corn agriculture which make corn biofuel more salient in the public mind

Cellulose biofuels

- advantageous because we don't need to eat cellulose
- waste products could then supply our energy needs
- wood waste
- paper pulp
- technically difficult

All various forms of energy have advantages and disadvantages Evaluating these trade-offs is a complex, often technical problem

1) How will we balance competing needs and desires for energy prosperity, safety, and environmental health?
2) Can nuclear power provide a safe option?
3) Would you raise fewer objections if there was a severe energy shortage?
4) Is increased energy generation essential for continued economic growth?

Agricultural land issues

"California is home to the most productive agricultural counties in the nation."
US Department of Agriculture, 2008

- our farms produce nearly half of the vegetables, fruits and nuts grown in the nation
- almonds, artichokes, olives, walnuts, and figs are commercially produced only in California
- CA is the nation's largest dairy producer
- of the state's 100 million acres, 25.4 million acres are dedicated to agriculture
- CA farms are on average smaller than the national average (312 acres vs 418 acres nationwide)
- we are doing more with less

Land conversion

a. the development and conversion of farmland to urban use
   - driven by rising population and higher land prices, which place pressure on farmland
   - throughout the Central Valley, about 30,000 acres converted annually from farmland to urban use

b. increased willingness to sell off family farms
   - children want to pursue other careers
   - farming is less profitable

c. significant losses in prime farmland from 1982 to 2007, but has since stabilized
   - planners advocating for higher density residential areas
   - agricultural conservation easements
   - novel financing arrangements to help farmers keep their land

Water Use

a. agriculture uses between 50-90% of the state's fresh water
   - most of the farm and ranch land is located in the drier southern half of the state.
   - a high percentage of water used in these southern farms is conveyed via aqueducts and dams from the north
   - supported by federal government and water subsidies that benefit large industrial growers

b. ecological concerns
   - coastal summer agricultural water need are met by tapping riparian and groundwater resources
     - this has effect of decreasing stream flow during dry season
   - contamination of ground and surface water by surface runoff of fertilizer and pesticides

Sustainable agriculture

a. agricultural lands can provide other things beyond ample food supply and substantial revenue
   - maintenance of open space
   - refuge for wildlife
   - possibility of locally based food systems

b. most if not all farmers and ranchers see themselves as guardians of the land
   - rather than focusing on only buying organic, an insistence on buying local food may go further in reducing our carbon footprint

c. has roots in traditional agriculture
   - integrates three main goals
     - environmental health
     - economic profitability
     - social/economic equity

d. uses a variety of approaches
   - selection of species and varieties well suited to the site
   - diversification of crops (including livestock)
   - management of the soil to protect and enhance its quality
   - efficient and humane use of animals
   - consideration of farmers' goals and lifestyle choices

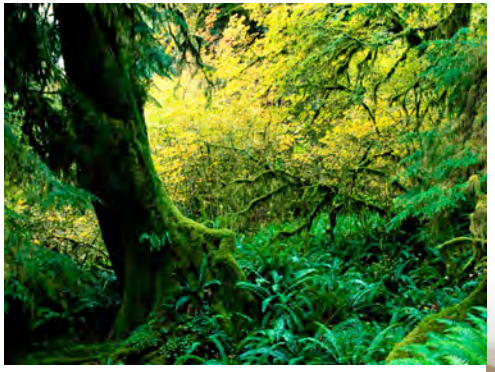
Global Environmental Challenges

"The first day or so, we all pointed to our countries. The third of fourth day, we were pointing to our continents. By the fifth day, we were aware of only one Earth."

The Discovery 5 Space Mission

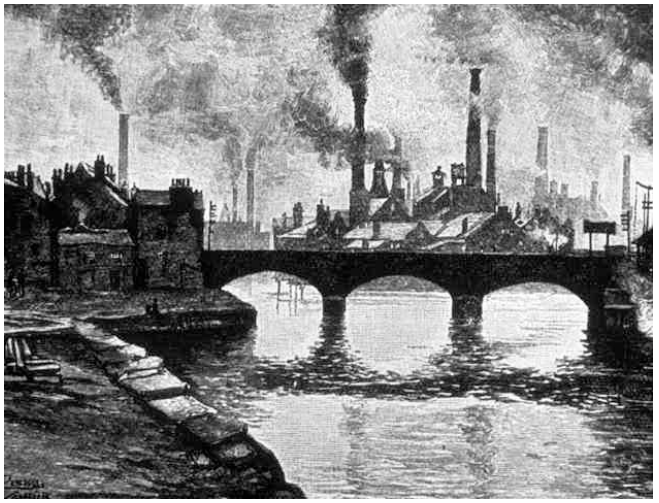
Global warming

a. atmospheric and climate change can be natural phenomena
   - the ancient atmosphere before the advent of green plants contained very little oxygen
   - the rise of plants eventually raised the concentration of atmospheric oxygen to 20%
   - annihilated many species, but opened the door for the existence of other species



- cold glacial cycles alternating with warm interglacial
- North American has at times hosted tropical forests, been buried under sheets of ice miles thick, or has been a dry and virtually lifeless desert

b. the most pressing global environmental problem of our time is human induced climate change
   - atmospheric chemical change took off with the start of the Industrial Revolution



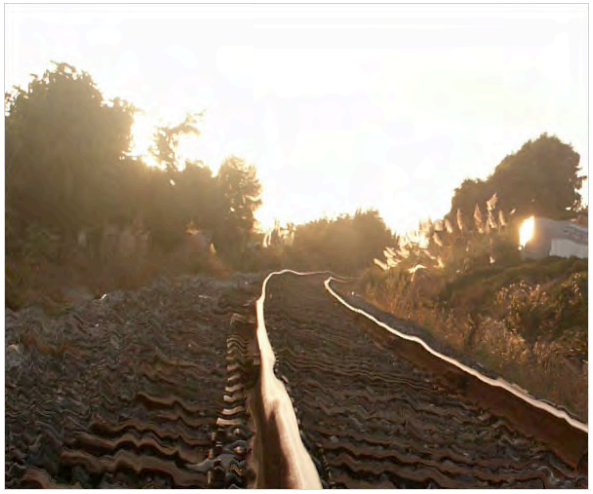
- greenhouse effect
  - heat-trapping blanket of greenhouse gases- primarily carbon dioxide, methane, and nitrous oxide- in the atmosphere
  - reflects heat that would otherwise escape out into space back towards the earth

Global Warming's projected impacts in CA

a. sea level rise, coastal flooding and coastal erosion
   - rising sea levels erode the coastline and cause greater storm surges
   - saltwater intrusion into the delta will threaten wildlife and drinking water for 20 million CA
   - warmer and more acidic ocean water will alter marine ecosystems and fog patterns

b. higher risk of fires
   - makes forests and brush drier

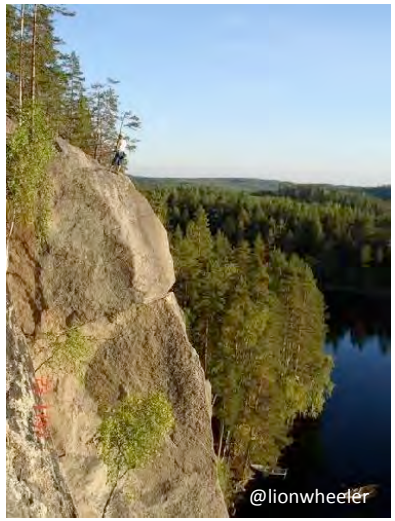
c. damage to agriculture
   - reduced precipitation
     - caused by northward shift of winter storms
     - leads to more severe summer drought



- rising temperature
  - 0.5-1 degrees increase by 2025 w/ more acute rises during summer
  - increase in heat wave days

- decreased summer soil moisture
- increased risk of pest infestations

d. habitat modification, destruction, loss of ecosystems
   - impairs ecosystem ability to provide clean water supplies, wildlife, fish & timber
     - ex. the lower edge of the forests in the Sierra Nevada have been retreating upslope over the past 60 years



   - small mammals in Yosemite found at higher elevations now

   - butterflies in Central Valley arriving earlier in the spring over the past four decades

e. reduction in CA water supply
   - the Sierra snowpack provides 65 percent of CA's water supply
   - projection of 25% loss of snow packs by 2050

- longer and more severe droughts
- general drying of the southwest US region
  - the probability of Lake Mead going dry by 2025 is 50%

- rising sea levels threaten Sacramento-San Joaquin Delta
  - source of water for 20 million CA residents
  - source of water for millions of acres of prime farmland

Dodging the climate change bullet

China and India (with about half of the world's population) currently emit less greenhouse gas per person than the US or Western Europe

But they are on a trajectory to overtake us

This would be a recipe for a climatic disaster

China

- consumes more coal than the US, EU and Japan combined
- every two weeks another coal-fired power plant opens up in China large enough to serve all the households in San Diego

- clearly we need to cooperate with rapidly developing countries and help them develop cleaner energy solutions

- increased emissions from developing countries are not a foregone conclusion
  - combination of new technologies, regulations, changes in consumption/ behavior will be essential

Reducing our carbon footprint can be fun

- walking and riding bikes
- going to farmer's markets
- planting a trees
- sharing with neighbors

Here are a few places to start (with annual carbon savings in pounds)

- replace a regular light bulb with compact fluorescent light bulb: 150 lbs

- drive less: 1 lb of C02 for every mile you don't drive

- check your tires: keeping your tires inflate properly improves gas mileage by more than 3%

- recycle at least half of your household waste: 2,400 lb

- use less hot water: it takes a lot of energy to heat water. Use less by installing low flow showerhead (350 lbs) and washing your clothes in cold or warm water (500 lbs saved per year).

- avoid products with lots of packaging: reduces your garbage and saves 2,000 lbs of C02 yearly

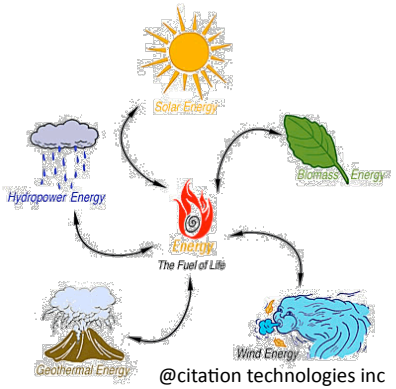
- plant a tree: a single tree will absorb one ton of carbon dioxide over its lifetime

- turn off electronic devices when not in use: 1,000 lbs of C02 per year

Additional suggestions

- teleconference, vacation locally, plan trips to reduce plane travel

- eat food grown locally: much of the food sold in supermarkets has been driven and flown thousands of miles



@citation technologies inc

- advocate for renewable energy: electricity generation produces 40 percent of carbon emissions for the US

The Nature Conservancy
Protecting nature. Preserving life.™

NRDC
THE EARTH'S BEST DEFENSE

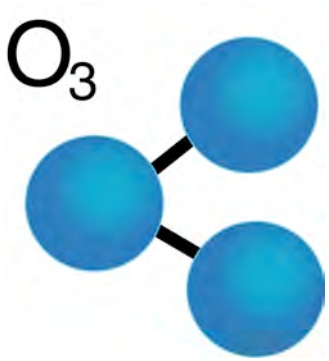
ociety for Conservation Biology

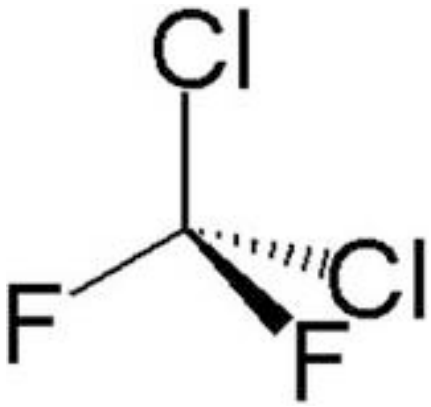
- support projects that restore and protect the ocean, forests, and wildlands

Ozone (O_3)depletion

Ozone

- ozone exists in small quantities in the stratosphere
- protects us from ultraviolet radiation



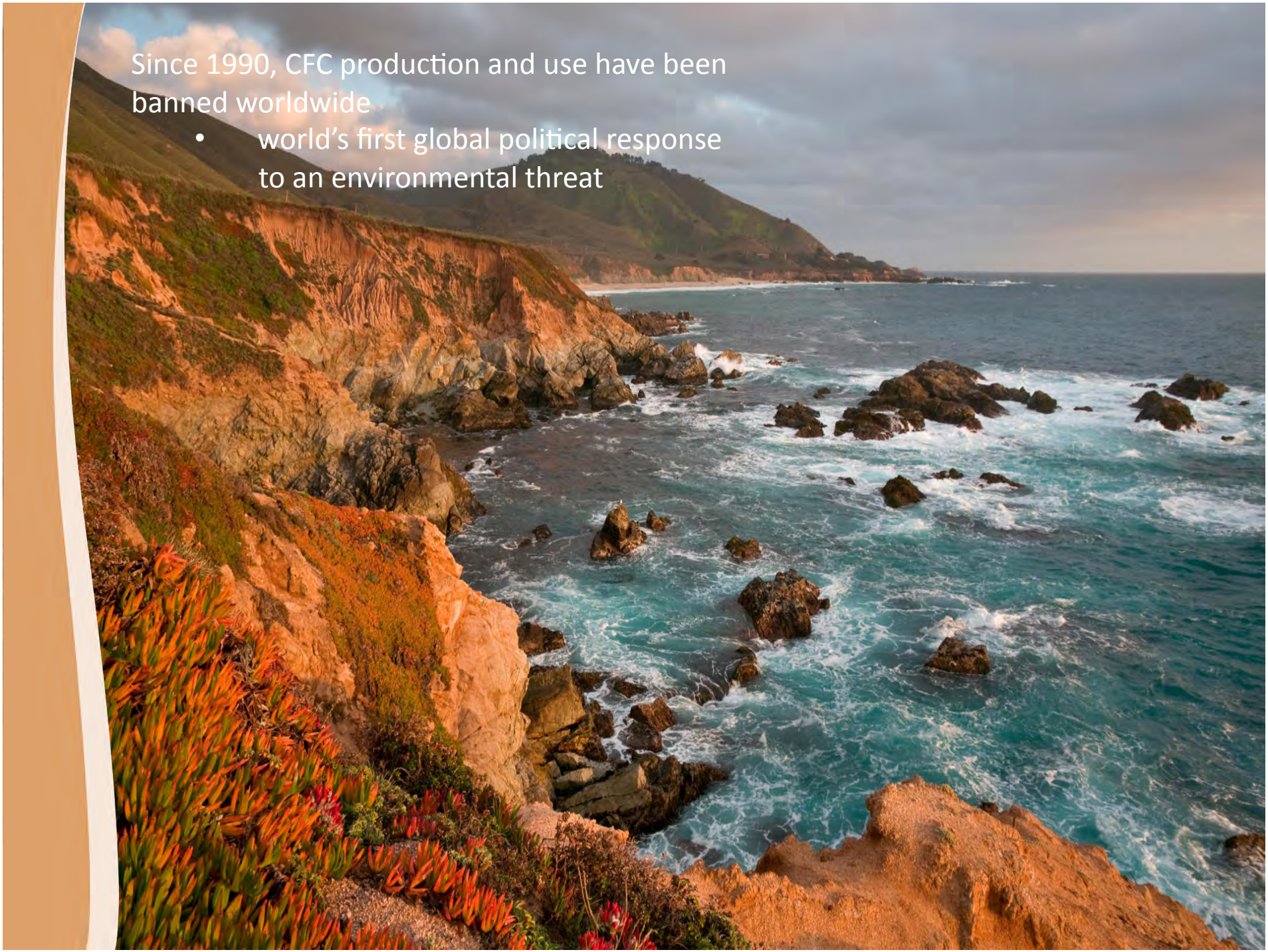


Chlorofluorocarbons (CFC's)

- 1920s, created by Thomas Midgley who was trying to create a substitute for dangerous gasses used in refrigerants
- quickly adopted across all walks of industry

We now know that CFC's are dangerous

- destroy ozone layer
  1. broken down by light to form chlorine and bromine atoms
  2. chlorine and bromine react with ozone to destroy it
- 10,000 times more potent as greenhouse gasses than carbon dioxide


Since 1990, CFC production and use have been banned worldwide
• world's first global political response to an environmental threat

Dead Zones, Fertilizers, Manure Management

- dead zones are low-oxygen areas in the world's oceans and lakes
- caused by eutrophication
- today 146 dead zones have been identified
  - some are small, but the largest one covers 70,000 square km
  - ex. Mississippi river collects agricultural runoff from Midwest, the breadbasket of the world
  - high concentration of fertilizer combined with animal waste make the runoff extremely high in nitrogen and phosphorus

- dead zones can be recovered
  - Black Sea dead zone was once the world's largest dead zone
  - disappeared following collapse of the Soviet Union and its subsidies of fertilizer use

Manure Management

- manure effects on ecology
  - nutrient poisoning of rivers
  - composting it creates methane, a greenhouse gas
  - 25X more potent than carbon dioxide

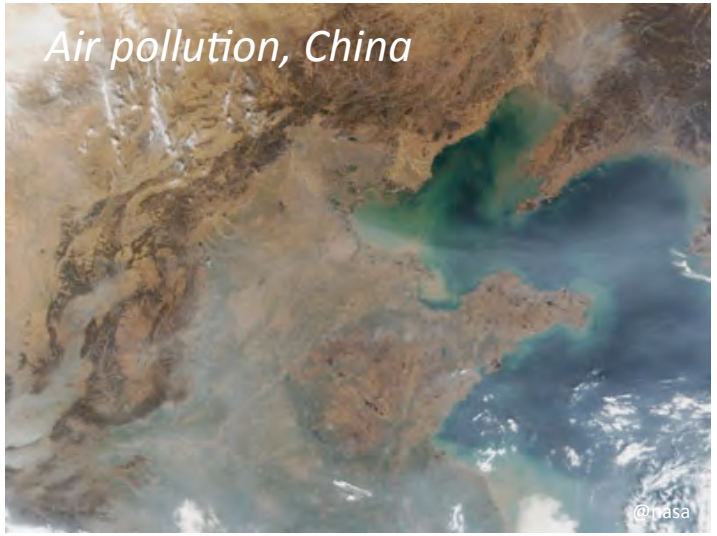
Air quality

- smog
  - in western states, mostly composed of ozone
  - formed from nitrogen oxides (NOx) and volatile organic compounds (VOC)
  - worst on warm, stagnant days

- transported between continents
  - rural areas in NorCA receive smog from ozone plumes moving across the ocean from Asia

- effects
  - difficulty breathing
  - worsening of asthma
  - reduces lung volume over long periods of time
  - reduces photosynthesis, growth, and root development in plants
  - marked by bronze speckling on the upper leaf surface

- particulate matter
  - consist of many chemical constituents/ fine particles from diverse sources
    - wood burning
    - diesel engine emissions
    - road and agricultural dust
    - coal fired power plants



Air pollution, China

  - effects
    - premature death in old or unhealthy populations
    - generally not damaging to vegetation unless containing high levels of nitrogen
    - cement dust, which is alkaline and corrosive and particles mixed with heavy metals are hazard for grazing animals and consumers of milk and meat

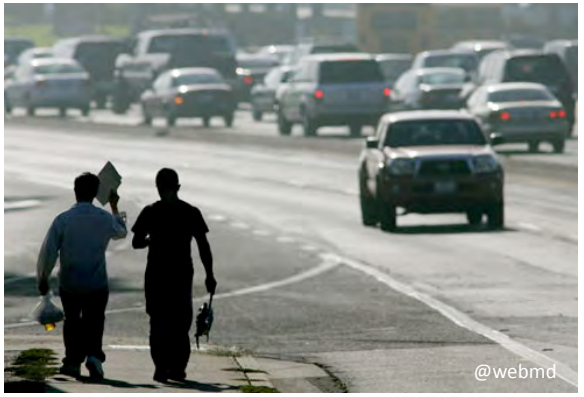
- sulfur dioxide (SO_2)
  - derived from burning coal
  - effects
    - asthma attacks
    - acid rain
    - particularly acute effects in Sierra Nevada, where pH buffering is weak
    - visibility degradation

  - effects
    - not harmful to plants
    - headache, chest pain, even rapid death in humans

- carbon monoxide
  - byproduct of incomplete combustion
  - automobile engines
  - campfires
  - other sorts of biomass burning
  - accumulates in valleys with little air movement, in caves, enclosed tents or automobiles

- carbon dioxide (CO_2)
  - primarily from vehicle exhaust

  - effects
    - warmer temperatures
    - exacerbates ozone air pollution
    - increases risk of wildfire, extension of fire season
    - further increases particulate matter and ozone concentrations in downwind communities



Solid Waste

In nature, there is no such thing as waste

- a tree dies and decomposes
- becomes food for fungi
- home for insects and birds
- later becomes a seed log for new trees

Humans on the other hand treat materials as if they can "go away"

- average CA generates 42 lbs of trash weekly
- every item we buy has "embodied energy"
- embodied energy is the energy that was used to get the product from its source to you
  - manufacturing
  - packaging
  - advertising
  - shipping from manufacturing center to commercial store
  - transportation from store to home
  - collection for recycling and landfilling

- when we fail to use something to its fullest potential, we:
  - waste materials comprising the product
  - waste resources that had gone into creating the product

Disposal

I. “trash day”
II. sorting and parsing of recyclable items at transfer station from waste stream
III. remaining waste trucked to landfill
    - gigantic hole lined with clay or plastic
    - space is becoming more scarce
    - decades to thousands of years to decompose

- as materials degrade, emit methane which is 25X more potent greenhouse gas than CO_2
    - food waste and organics are biggest generators of methane
    - amplifies importance of composting food and organics

- nearly half of US landfills have been closed due to groundwater contamination
- covered with soil to shield from rain, wind, sun, air

Its difficult to build new landfills due to "not in my backyard" mentality

- trucking of garbage far away at great expense.
- San Francisco hauls all its trash over 50 miles to Livermore, CA
- Los Angeles is considering long rail hauling of their garbage for disposal in Mojave Desert

Flickr: juicyrai

CA's efforts

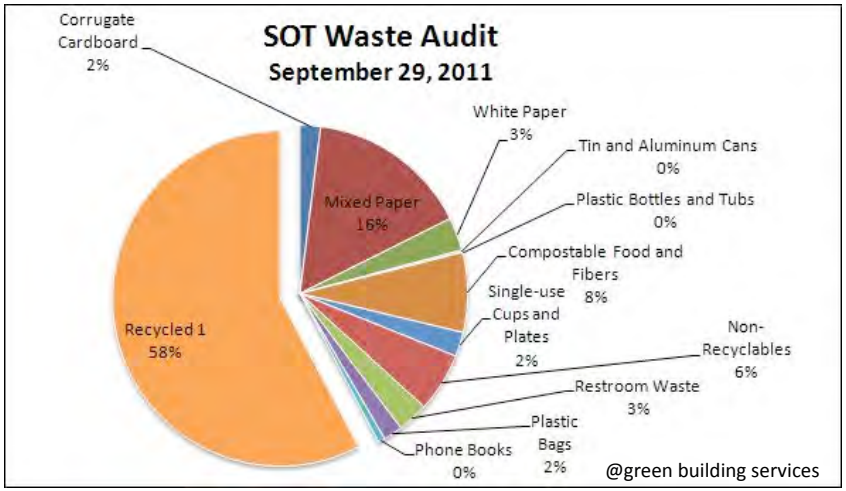
- improved waste reduction and recycling rates due to new laws
- we still throw away a third of our bottles/cans and recycling <50% of our paper

Recycling achieves huge savings in energy

- ex. recycling aluminum can save 95 % of energy required to make same amount of aluminum from its virgin source

How does your household stack up?

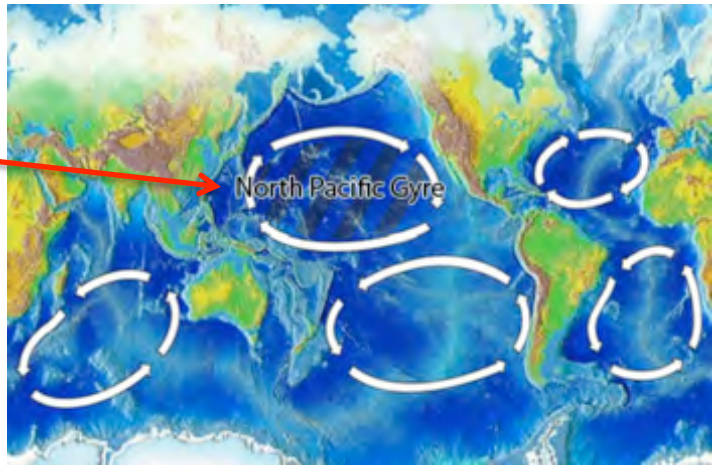
I. write down everything you think you would find in your weekly garbage
II. assign predicted percentages to each type of trash
III. now go through garbage before trash day and sort it out
IV. use gloves and maybe goggles



V. ask yourself questions
- How much of this could have been recycled?
- How much composted?
- Why did I buy this product in the first place?
- Did I use it fully?
- Could I have bought something similar that could have been reused, recycled, or composted?

Masses of garbage, mostly plastic, swirl around the world's oceans

- largest one is the Great Pacific Garbage Patch
  - twice as large as the state of Texas
  - heavier than all the plankton living in the northern Pacific Ocean
  - extends up to 10 feet below surface
  - sea life mistake plastic as food



- 80% of the patch comes from land sources
  - packaging and plastic bags left on beaches, littering creeks, blown from highways to storm drains
  - is it time to ban plastic bags?

These four Rs help us see products as part of the natural material cycle

- Reduce
- Reuse
- Recycle
- Rot (compost)

Oakland and San Francisco have set the example by setting the exciting and ambitious goal of generating *zero waste* by 2020

Manufacturers in the solid waste solution

- often have greatest ability to reduce environmental impacts of their products
- process of rethinking their products, their relationships with the supply chain and the ultimate consumer is good for business
  - increases productivity
  - cuts costs
  - fosters product and market innovation
  - provides customers with more value at less environmental impact

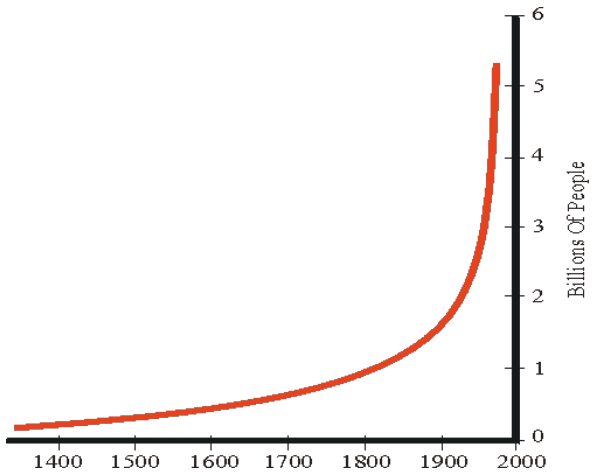
Tips to reduce your trash footprint

- buy less
- buy products with little or no packaging
- try items that can be reused
  - cloth bags for shopping
  - cloth napkins for meals
  - dish towels for the kitchen
- buy gently used toys, clothes and furniture at garage sales, but NOT old electronics (which can be hazardous)
- choose lasting, durable items
- buy/build compost bin
  - recycling at your home
  - no transportation costs
  - useful for your garden

Population

All of the previously mentioned problems are outgrowths of the size of the human population

a. grew slowly for most of the 4.5 million years we have existed, hovering a around 5 million people
b. invention of agriculture about 11,000 years ago led to the first spike



c. following 9,000 years saw human population expand to 300 million
   - By 1650, 130 million
   - By 1800, 1 billion
   - By 1930, 2 billion
   - By 1960, 3 billion
   - By 1974, 4 billion
   - By 1987, 5 billion
   - By 1999, 6 billion

d. though the world population growth rate has fallen from its peak at 2 %/yr to 1.3%/yr, it is expected to increase substantially during the 21st century
   - UN projections suggest that world population will stabilize at just above10 million by 2200

CA population

a. by 2008: 38,246,598
   - most dense around coastal counties

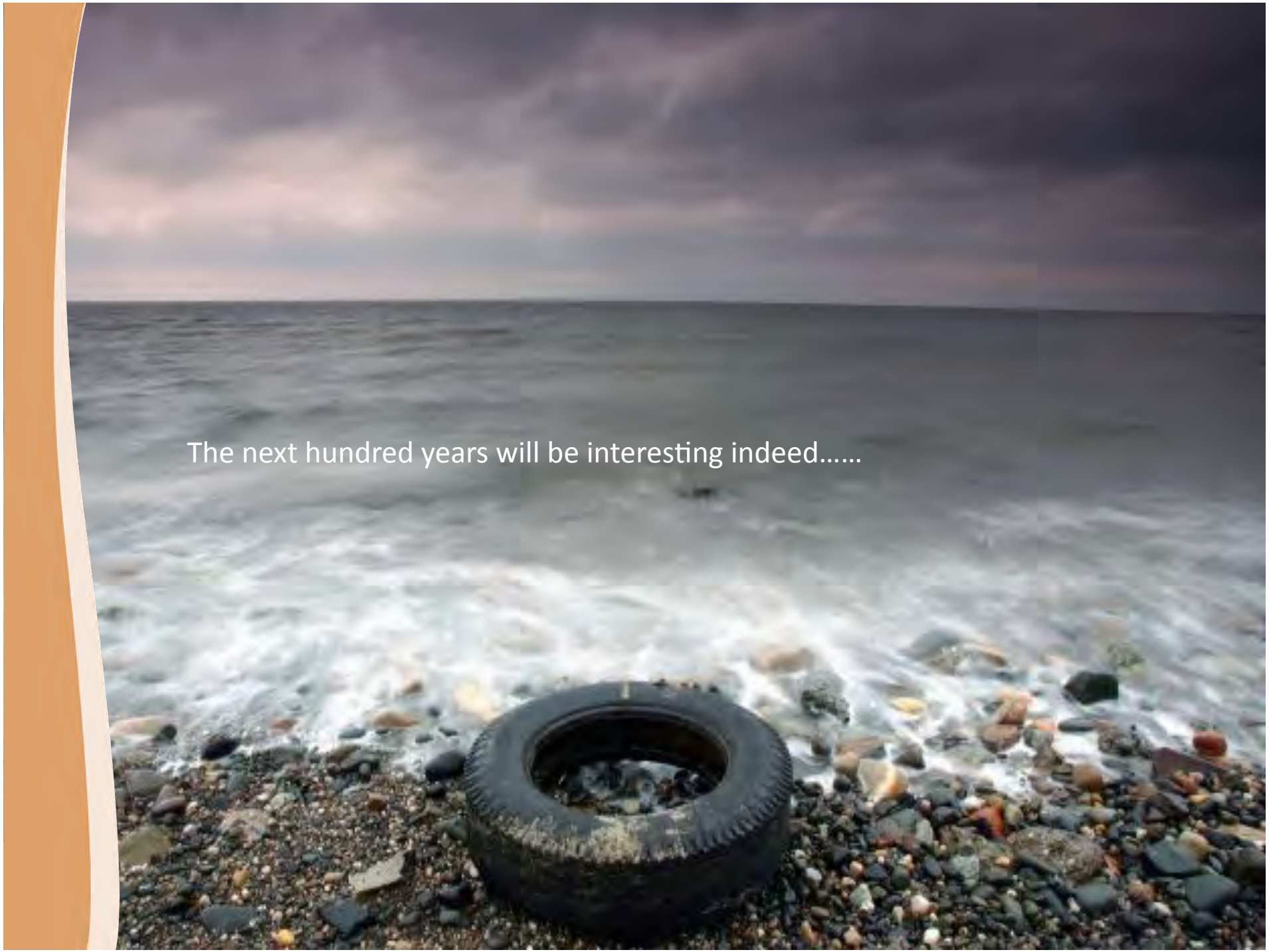
b. by 2025, expected to be 46,720,307
   - driven by births and immigrations
   - 17% increase in coastal counties
   - 45% increase in inland counties

c. a tenacious situation considering that inland temperatures are projected to rise dramatically!

d. age distribution
   - in 2008, 14% of population is age 60 or older
   - by 2030, this proportion will increase to 24%

Conclusion

I. We live on one planet, with nowhere else to go
II. We are rapidly reaching the limits of human population and resource use that the planet can support
III. We are creating global environmental dangers unprecedented in human history
IV. We have unprecedented technological tools to overcome these problems that no previous generation has possessed


The next hundred years will be interesting indeed……