**Ch. 15 Freshwater Resources: Natural Systems, Human Impact, and Conservation**

**Freshwater systems**

* Water may seem abundant, but drinkable water is rare
* **\_\_\_\_\_\_\_\_\_\_\_\_\_\_** = relatively pure, with few dissolved salts
  + Only 2.5% of Earth’s water is fresh
  + Most freshwater is tied up in \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Rivers and streams wind through landscapes**

* Water from rain, snowmelt, or springs forms streams, creeks, or brooks
* These merge into rivers, and eventually reaches the ocean
  + **\_\_\_\_\_\_\_\_\_\_\_\_\_\_** = a smaller river slowing into a larger one
  + **\_\_\_\_\_\_\_\_\_\_\_\_\_\_** = the area of land drained by a river and its tributaries
  + If there is a large bend in the river, the force of the water cuts through the land
  + **\_\_\_\_\_\_\_\_\_\_\_\_\_\_** = an extreme bend in a river
  + **\_\_\_\_\_\_\_\_\_\_\_\_\_\_**= the bend is cut off and remains as an isolated, U-shaped body of water

**A river may shift course**

* **Floodplain** = areas nearest to the river’s course that are flooded periodically
* **Riparian =**
  + It connects the upland zone to the aquatic zone, controlling the flow of water, sediment, nutrients, and organisms between the two.

**Ecological Services of Rivers:**

**Wetlands include marshes, swamps, and bogs**

* **\_\_\_\_\_\_\_\_\_\_\_\_\_\_** = systems that combine elements of freshwater and dry land
* **\_\_\_\_\_\_\_\_\_\_\_\_\_\_**= shallow water allows plants to grow above the water’s surface
* **\_\_\_\_\_\_\_\_\_\_\_\_\_\_**= shallow water that occurs in forested areas
  + Can be created by beavers
* **\_\_\_\_\_\_\_\_\_\_\_\_\_\_** = ponds covered in thick floating mats of vegetation
  + A stage in aquatic succession

**Wetlands are valuable**

* Wetlands are extremely valuable for wildlife
* They slow runoff
  + Filter pollutants
* People have drained wetlands, mostly for agriculture
  + Southern Canada and the U.S. have lost more than half of their wetlands

**Lakes and ponds are ecologically diverse**

* Lakes and ponds are bodies of open, standing water
* **\_\_\_\_\_\_\_\_\_\_\_\_\_\_**= region ringing the edge of a water body
* **\_\_\_\_\_\_\_\_\_\_\_\_\_\_**= extends along the entire bottom of the water body
  + Home to many invertebrates
* **\_\_\_\_\_\_\_\_\_\_\_\_\_\_**= open portions of the lake or pond where the sunlight penetrates the shallow waters
* **\_\_\_\_\_\_\_\_\_\_\_\_\_\_**= water that sunlight does not reach
  + Supports fewer animals because there is less oxygen

**Lakes vary in their nutrients and oxygen**

* **Oligotrophic** lakes and ponds =
* **Eutrophic** lakes and ponds =

**Groundwater plays a key role**

* **\_\_\_\_\_\_\_\_\_\_\_\_\_\_** = any precipitation that does not evaporate, flow into waterways, or gets taken up by organisms
  + Groundwater makes up one fifth of the Earth’s freshwater supply
* **\_\_\_\_\_\_\_\_\_\_\_\_\_\_** = Porous sponge-like formations of rock, sand, or gravel that hold groundwater
* **\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**= pore spaces are partially filled with water
* **\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**= spaces are completely filled with water
* **Water table** = boundary between the two zones
* **Aquifer recharge zone** = any area where water infiltrates Earth’s surface and reaches aquifers

**There are two categories of aquifers**

* **\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**= water-bearing, porous rocks are trapped between layers of less permeable substrate (i.e., clay)
  + Is under a lot of pressure
* **\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**= no upper layer to confine it
  + Groundwater becomes surface water through springs or human-drilled wells
* Groundwater may be ancient: the average age is 1,400 years

**The Ogallala Aquifer**

* Underlies the Great Plains of the U.S.
* Its water has allowed farmers to create the most bountiful grain-producing region in the world

**We are depleting groundwater**

* + - Groundwater is easily depleted
  + 1/3 of world population relies on groundwater
* As aquifers become depleted
  + Water tables drop
  + **\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_** = areas where ground gives way unexpectedly
  + Some cities (Venice, Mexico City) are slowly sinking
  + Wetlands dry up

**Water is unequally distributed across Earth’s surface**

* Different regions possess vastly different amounts of groundwater, surface water, and precipitation
* Many areas with high population density are water- poor and face serious water shortages

**Water is distributed unevenly in time, too**

* Monsoon seasons bring concentrated storms
  + Half a region’s annual rain may fall in a few hours
* People erect dams to store water

**Climate change will cause water shortages**

* Climate change will cause
  + Altered precipitation patterns
  + Early season runoff
  + Flooding
* Increasing probability that there will be still less water for more people

**How we use water**

* We have achieved impressive engineering accomplishments to harness freshwater sources
  + 60 % of the world’s largest 227 rivers have been strongly or moderately affected
  + Dams, canals, and diversions
* Consumption of water in most of the world is unsustainable
  + We are depleting many sources of surface water and groundwater

**Water supplies \_\_\_\_\_\_\_\_\_\_\_, \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_, and \_\_\_\_\_\_\_\_\_\_**

* Proportions of these three types of use vary dramatically among nations
  + Arid countries use water for agriculture
  + Developed countries use water for industry

**Different types of water use**

* **\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_=** water is removed from an aquifer or surface water body, and is not returned
* **\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**= does not remove, or only temporarily removes, water from an aquifer or surface water
  + Electricity generation at hydroelectric dams

**We have erected thousands of dams**

* **Dam** = any obstruction placed in a river or stream to block the flow of water so that water can be stored in a reservoir
  + To **\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**, provide drinking water, **\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**, and generate **\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**
  + 45,000 large dams have been erected in more than 140 nations
* Only a few major rivers remain undammed
  + In remote regions of Canada, Alaska, and Russia

**China’s Three Gorges Dam**

* The dam, on the Yangtze River, is the largest in the world
  + 186 m (610 feet) high, 2 km (1.3 mi) wide
  + Its reservoir stretches for 616 km (385 mi)
  + Provides flood control, passage for boats, and electricity

**Drawbacks of the Three Gorges Dam**

* Cost $25 billion to build
* Is flooding 22 cities and the homes of 1.13 million people
* Submerging 10,000-year-old archaeological sites
* Tidal marshes at the Yangtze’s mouth are eroding
* China will spend $5 billion to build sewage treatment plants

**Benefits and drawbacks of dams**

* *Benefits:*
  + Power generation
  + Emission reduction
  + Drinking water
  + Shipping
  + New recreational opportunities
* *Drawbacks*:
  + Fisheries declines
  + Population displacement
  + Disruption of flooding
  + Lost recreational opportunities

**Some dams are being removed**

* Some people feel that the cost of dams outweighs their benefits
  + They are pushing to dismantle dams
* Rivers with dismantled dams
  + Have restored riparian ecosystems
  + Reestablished fisheries
  + Revived river recreation
* 500 dams have been removed in the U.S.
  + Property owners who opposed the removal change their minds once they see the healthy river

**Dikes and levees are meant to control floods**

* Flooding is a normal, natural process
* Floods also do tremendous damage to property
* Dikes and levees (long, raised mounds of earth) along the banks of rivers hold rising waters in channels
  + The U.S. Army Corps of Engineers has constructed thousands of miles of levees
* Levees can make floods worse by forcing water to stay in channels and overflow

**We divert – and deplete – surface water**

* The Colorado River is heavily diverted
  + What water is left after all the diversions comprises just a trickle into the Gulf of California
    - On some days, water does not reach the gulf
  + Diversion has drastically altered the river’s ecology

**The Aral Sea**

* Once the fourth-largest lake on Earth
  + It has lost more than 80% of its volume in just 45 years
  + The two rivers leading into the Aral Sea were diverted to irrigate cotton fields
* Consequences of a shrinking sea
  + Pesticide-laden dust from the lake bed is blown into the air
  + The cotton cannot bring back the region’s economy

**Will we see a future of water wars?**

* Freshwater depletion leads to shortages, which can lead to conflict
  + Water is a key element in hostilities among Israel, Palestinians, and neighboring countries
* Many nations have cooperated with neighbors to resolve disputes

**Desalinization “makes” more water**

* **\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_** = the removal of salt from seawater or other water of marginal quality
  + **Distilling** = hastens evaporation and condenses the vapor
  + **\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**= forces water through membranes to filter out salts
* Desalinization facilities operate mostly in the arid Middle East
* It is expensive, requires fossil fuels, and produces concentrated salty water

**The world’s largest reverse osmosis plant**

* Near Yuma, Arizona
* Intended to reduce the salinity of irrigation runoff
* Too expensive to operate and closed after 8 months

**Agricultural demand can be reduced**

* Look first for ways to decrease agricultural demand
  + Low-pressure spray irrigation that spray water downward
  + **\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**that target individual plants
  + Match crops to land and climate
  + **\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_** and genetic modification to raise crops that require less water

**Residential demand can be reduced**

* Install **\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**, showerheads, washing machines, and toilets
* Water lawns at night, when evaporation is minimal
* **\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**
* **Xeriscaping** = landscaping using plants adapted to arid conditions

**Industrial demand can be reduced**

* Shift to processes that use less water
  + Excess surface water runoff used for recharging aquifers
  + Auditing industries

**Economic approaches to water conservation**

* End government subsidies of inefficient practices
  + Let the price of water reflect its true cost of extraction
* **\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_** are more profitable than agricultural
  + Less developed countries suffer
* **\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_** of water supplies
  + May improve efficiency
  + Firms have little incentive to provide access to the poor
* **\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**f water control may conserve water
  + Shift control to the local level

**Freshwater pollution and its control**

* Water for human consumption and other organisms needs to be…
* Half of the world’s major rivers are seriously depleted and polluted
  + They poison surrounding ecosystems
  + Threaten the health and livelihood of people
* The invisible pollution of groundwater has been called a “covert crisis”

**“***The United Nations has estimated that by 2025, at least 3 billion of the world’s projected 7.9 billion people will lack access to safe water.”*

**Nutrient pollution**

* **Pollution *=*** the release of matter or energy into the environment that causes undesirable impacts on the health and well-being of humans or other organisms
* Nutrient pollution from **\_\_\_\_\_\_\_\_\_\_\_**, farms, **\_\_\_\_\_\_\_\_\_\_\_\_\_\_**, lawns, golf courses
* Solutions
  + - Planting vegetation to increase nutrient uptake
    - Reduce fertilizer application

**Eutrophication is a natural process, but…**

* Human activities dramatically increase the rate at which it occurs

**Pathogens and waterborne diseases**

* Enters water supply via inadequately treated human waste and animal waste via feedlots
* Causes more human health problems than any other type of water pollution
* Currently, 1.1 billion people are without safe drinking water
* **\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**indicate fecal contamination of water
  + The water can hold other pathogens, such as giardiasis, typhoid, hepatitis A
* Solutions:
  + Disinfect drinking water
  + Public education to encourage personal hygiene
  + Government enforcement of regulations

**Toxic chemicals**

* From natural and synthetic sources
  + **\_\_\_\_\_\_\_\_\_\_\_\_\_\_**, petroleum products, **\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**
* Effects include: poisoning animals and plants, altering aquatic ecosystems, and affecting human health
* Solutions:
  + Legislating and enforcing more stringent regulations of industry
  + Modify industrial processes
  + Modify our purchasing decisions

**Sediment pollution**

* Sediment can impair aquatic ecosystems
  + Clear-cutting, mining, poor cultivation practices
  + Solutions: better management of farms and forests; avoid large-scale disturbance of vegetation

**Thermal pollution**

* + Warmer water holds **\_\_\_\_\_\_\_\_\_\_\_\_\_\_**
  + **\_\_\_\_\_\_\_\_\_\_\_\_\_\_**decreases as **\_\_\_\_\_\_\_\_\_\_\_\_\_\_** increases
  + Industrial cooling heats water
  + Removing streamside cover also raises water temperature
* Water that is too cold causes problems
  + Water at the bottom of reservoirs is colder
  + When water is released, downstream water temperatures drop suddenly and may kill aquatic organisms

**Water Pollution Comes from Point and Nonpoint Sources**

* + - **\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**
  + Located at specific places
  + Often discharge pollutants through drain pipes, sewer lines
  + Easy to identify, monitor, and regulate
  + Examples: factories, sewage treatment plants, underground mines, oil tankers
* **\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**
  + Broad, diffuse areas
  + Difficult to identify and control
  + Expensive to clean up
  + Examples: runoff of chemicals and sediment from cropland, livestock feedlots, golf courses, parking lots, urban streets

**Indicators of water quality**

* Scientists measure properties of water to characterize its quality
  + Biological indicators: presence of fecal coliform bacteria and other disease-causing organisms
  + Chemical indicators:
  + Physical indicators: **\_\_\_\_\_\_\_\_\_\_\_\_\_\_**, color, **\_\_\_\_\_\_\_\_\_\_\_\_\_\_**

**Sources of groundwater pollution**

* Some toxic chemicals occur naturally
* Pollution from human causes
  + Pathogens enter through improperly designed wells
  + Hazardous wastes are pumped into the ground

**Agriculture and industries pollute groundwater**

* Agricultural pollution
  + Pesticides were detected in more than half of the shallow aquifers tested
* Manufacturing industries and military sites have been heavy polluters

**U.S. Water Pollution Laws**

* + Mandates the restoration and maintenance of the chemical, physical, and biological integrity of the nation’s waters.
  + Targeted Industrial Discharges, Addressed Point Source Pollution
  + Requires minimum safety standards for community water supplies. EPA sets the standards

**Treating wastewater**

* **\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_** = water that has been used by people in some way
  + Sewage, showers, sinks, manufacturing, storm water runoff
* **\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_** = the most popular method of wastewater disposal in rural areas
  + Underground septic tanks separate solids and oils from wastewater
  + The water drains into a drain field, where microbes decompose the water
  + Solid waste needs to be periodically pumped and landfilled

**Municipal sewer systems**

* In populated areas, sewer systems carry wastewater
  + Physical, chemical, and biological water treatment
* **\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**= the physical removal of contaminants in settling tanks (clarifiers)
* **\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**= water is stirred and aerated so aerobic bacteria degrade organic pollutants
  + Water treated with \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ is piped into rivers or the ocean
  + Some reclaimed water is used for irrigation, lawns, or industry