



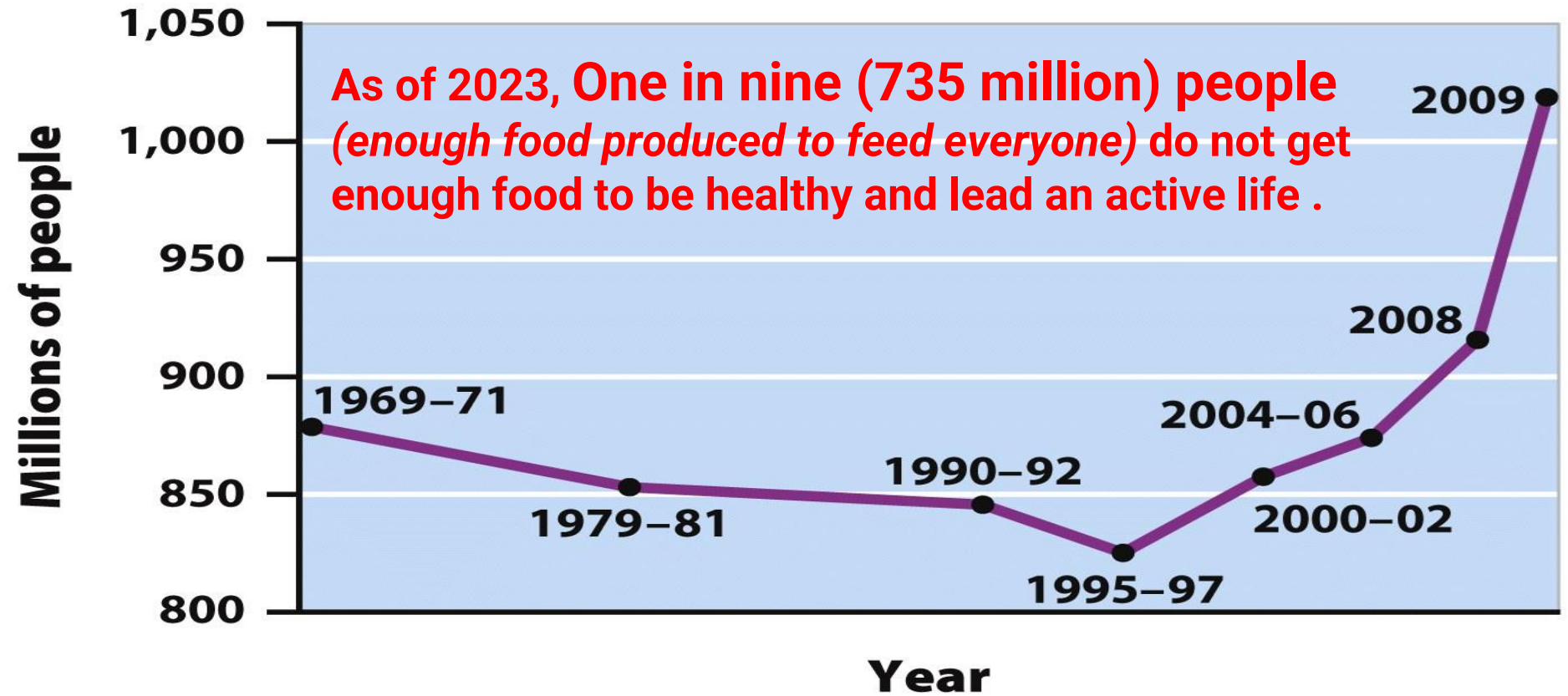
Chapter 11

Feeding the World

Nutritional Requirements

- **Undernutrition**- (chronic hungry) **not consuming enough calories** (energy deficit) to be healthy.
- **Malnourished**- a persons **diet lacks the correct balance** of proteins, carbohydrates, vitamins, and minerals even though they get enough calories.
- **Overnutrition**- **too many calories and improper foods** that causes a person to become overweight.
 - According to WHO (World Health Organization), **over 3.12 Billion people in the world are overweight (2016 it was 1.9 Bil)** (*39% global, 42% US...1 in 3 adults, 1 in 5 children are obese*)...*In 2008, 23.6% globally*

Global Undernutrition



~1 Bill. people world-wide lack access to adequate amt of food. An explanation could be due to increase fuel prices and global economic downturns (As Nov 2022, inflation rate is up 7.1%(highest since 1982), energy up 13%, gas up 65.1%, clothing up 3.6%, automotive up 7.4%, food up 10.6%) As of Nov. 2023, inflation rates slowed to 3.2% (lowest reading in 5 months)

Typical annual average over the past 10yrs have been 2%,

Reasons for Undernutrition and Malnutrition

- **Poverty** – **lack of resources** that allow one access to food (can't afford it)
- **Political and economic factors** (refugees that fled from home due to war or natural disaster, committed crimes due to lack of food, inadequate food supplies allow only certain “people” in status get resources)
- **Agricultural resources** being diverted to **feed livestock and poultry rather than people** (40% goes to livestock – low efficiency of energy transfer causes much of the energy to be lost from the system – food chain trophic levels)

Annual Meat Consumption

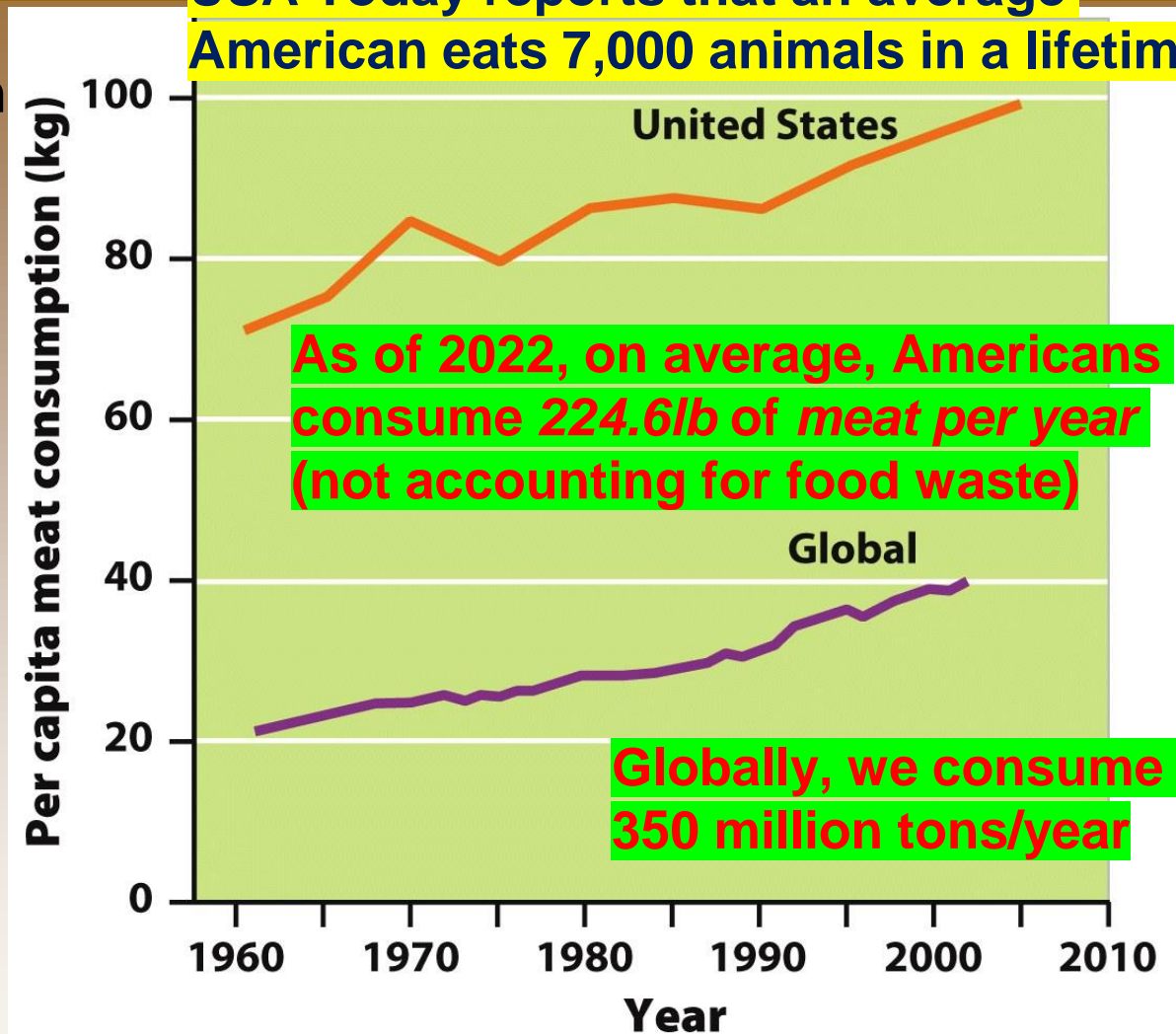
Second largest component of the human diet, after the consumption of grain (corn, rice, wheat, rye)
Fish is 3rd major source.

As income increases (economic growth), consumption of meat occurs

Scary fact:

~22mil. gallons of gas used annually to transport food that is thrown away!!

USA Today reports that an average American eats 7,000 animals in a lifetime.



Predicted by 2030, the global consumption will be 453 million...44% increase

High-Density Animal Farming

- CAFOs (concentrated animal feeding operations)- large structures where animals are being raised in high density numbers (very little area to move).

Consequences:

~increase in **antibiotic-resistance strains** of microorganisms that affect humans (**meat recalls**)
~**Waste disposal**, nutrient runoffs problems of synthetic fertilizers in waterways (**groundwater contamination crop recall**)

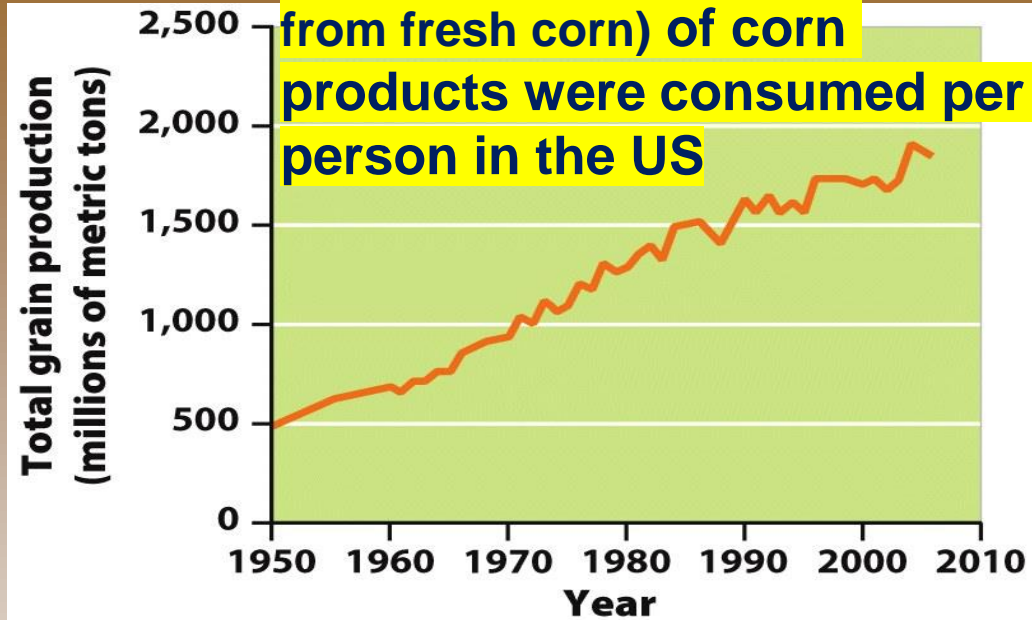
Free-range farms – more land use, higher price point for consumers, but less/no use of antibiotics, no feeding supplements-from natural land



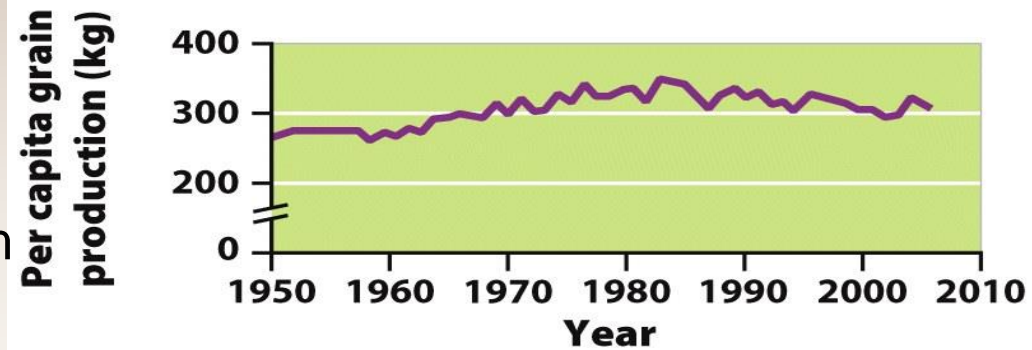
Figure 11.19
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Global Grain Production, 1950-2006

In 2019, 36.5lbs (only 4.4lbs is from fresh corn) of corn products were consumed per person in the US



(a) Total grain production



(b) Per capita grain production

Global grain production grew 1950s-1980s, growth since has slowed down.

on average, Americans consume 26lb of rice per year & Asians consume 300lb

Global per capita grain production has leveled off and may be starting to decline.

40% of grain is used to feed livestock (corn & soybean)

Influences of grain productions are:

1. amt. of land cultivation
2. global weather precipitation & patterns
3. world prices
4. productivity from land.

As of 2021, on average, Americans consume 134lb of wheat per year (not accounting for food waste)

Harvesting of Fish and Shellfish

- **Fishery**- a **commercially harvestable population** of fish within a particular ecological region.
- **Fishery collapse**- the decline of a fish population by 90% or more.
- **Bycatch**- **unintentional catch of non-target** species, significantly reduced population of fish species such as sharks & endangered species.

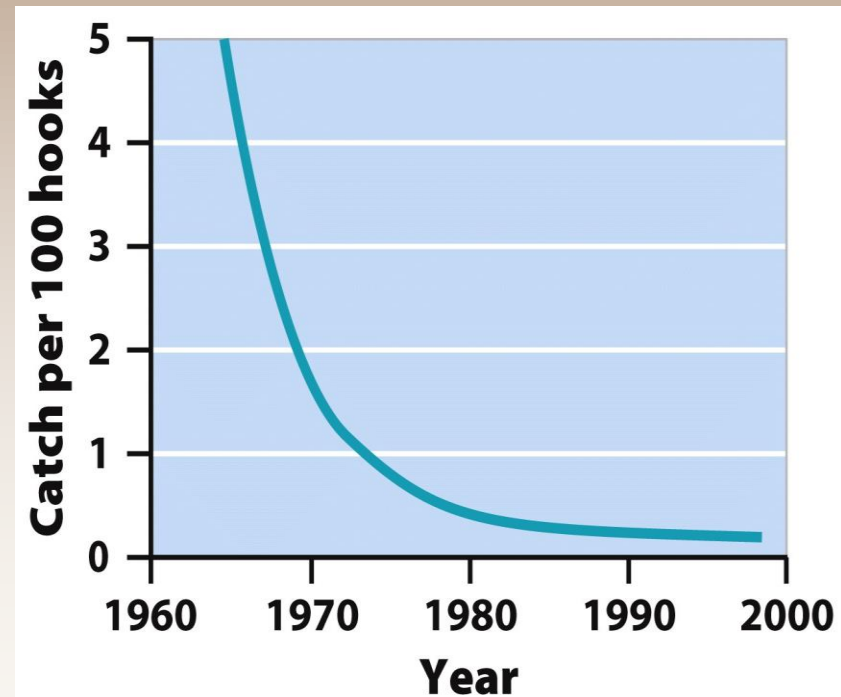


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Sustainable Fishing-

Overfishing can deplete fish faster than breeding seasons (stock).

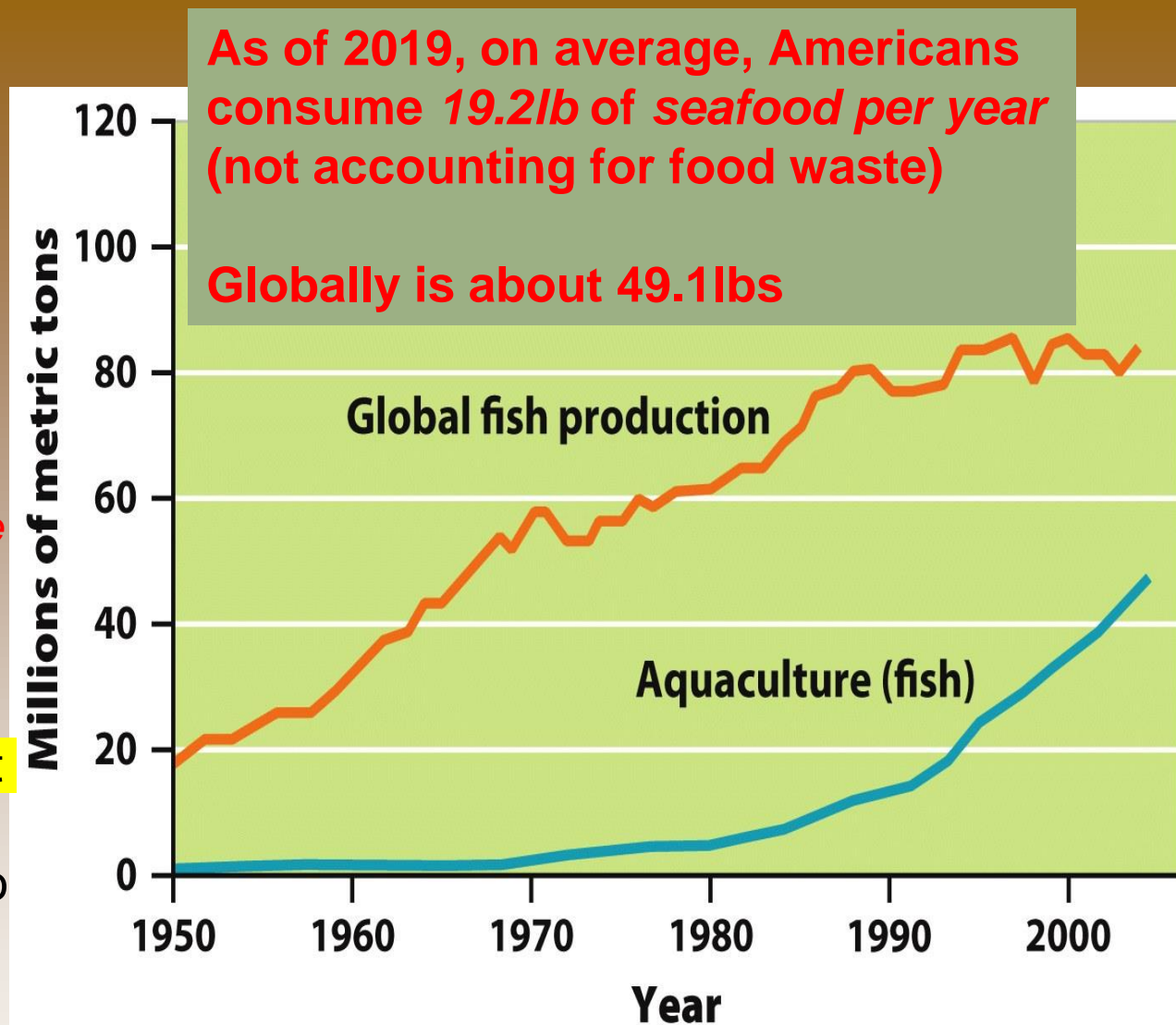
Regulations:

TAC (total allowable catch... total fish)

ITQ (individual transferable quotas...everyone gets set amt of fish)

Sustainable Fisheries Act

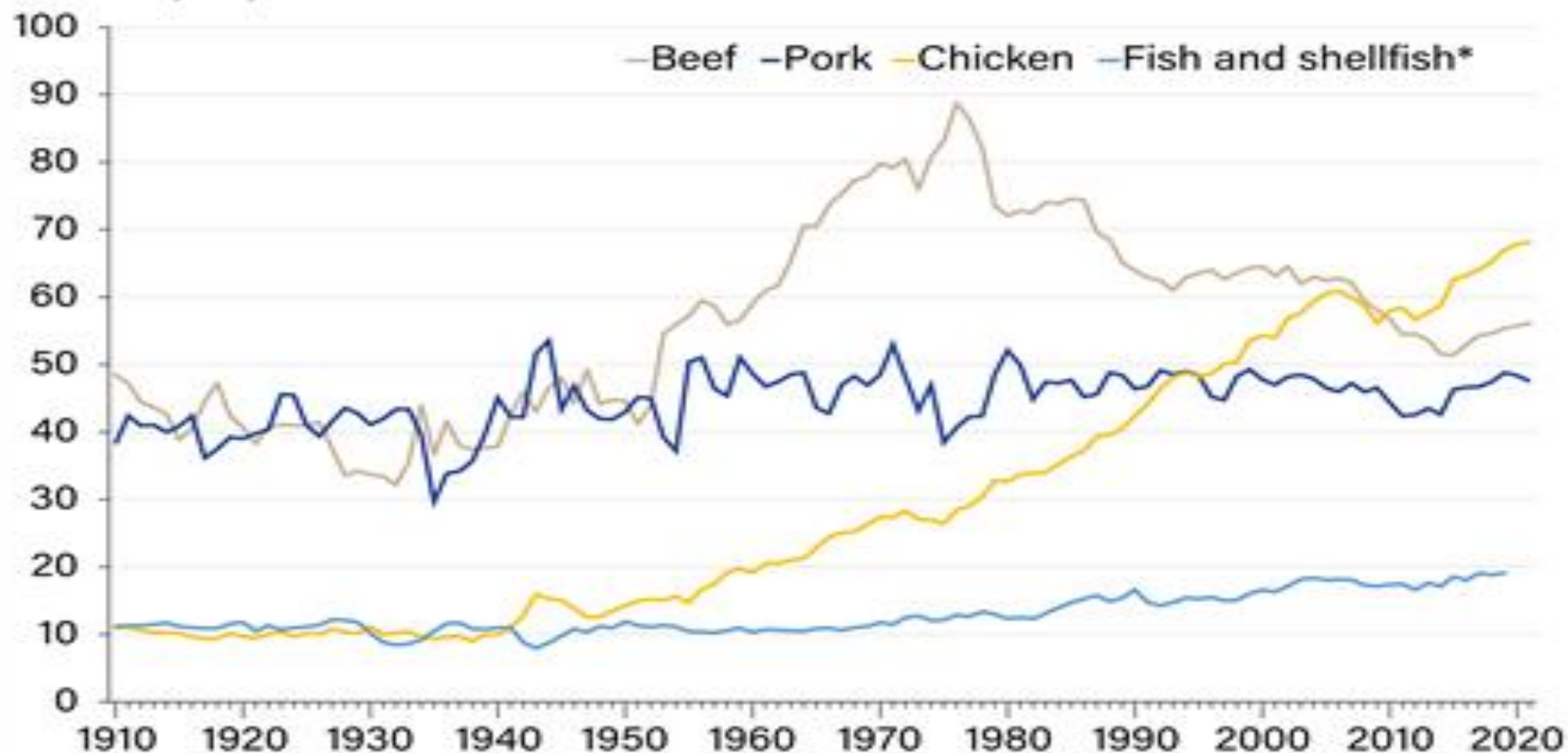
of 1996 - shift focus on economic sustainability to an increase species-sustainability (protection of critical marine habitat – commercial and nontarget species)



Global fish production has increased more than 20% since 1980, primarily as a result of the large increase of aquaculture, still on a raise.

U.S. per capita availability of beef, pork, chicken, and fish/shellfish, 1910-2021

Pounds per person¹



¹Calculated on the basis of raw and edible meat in boneless, trimmed (edible) weight. Excludes edible offals, bones, viscera, and game from red meat. Includes skin, neck, and giblets from chicken. Excludes use of chicken for commercially prepared pet food.

*Fish and shellfish data are only available through 2019.

Source: USDA, Economic Research Service, Food Availability Data.

Aquaculture – Fish Farming

- **Aquaculture**- the **farming of aquatic organisms** such as fish, shellfish, and seaweeds **(increase the production of seafood)...**like farming cattle

Constructing an aquatic ecosystem by *stocking the organism, feeding them, and protecting them from disease & predators (controlled)* as a mean of **sustainable food production.**

Potential to boost the economics of many developing countries

Environmental problems such as **pumping wastewater** from pond or marine enclosure containing feces (bacteria, virus, and pests), uneaten food, antibiotics is pumped back into the river or ocean (can infect wild fish or shellfish), **mix of native & non-native, herbicide (chemicals) use to control algae**

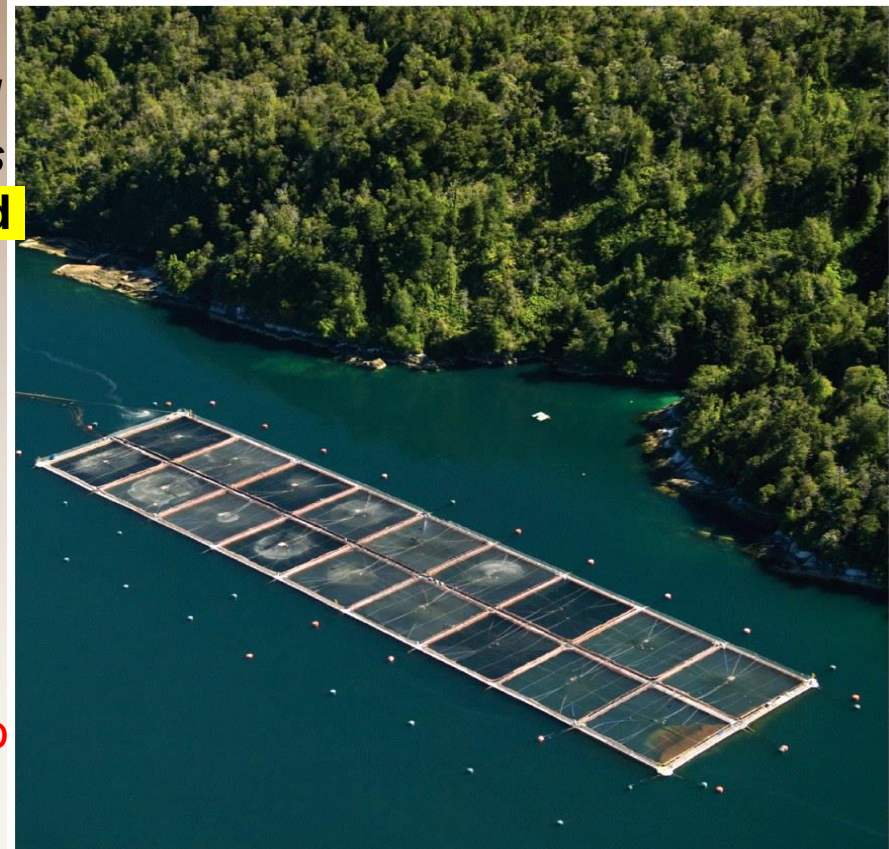


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Irrigation Problems

- Beneficial based on efficient use of water in some places where water is scarce.....

Negative Consequences:

- ~Deplete *groundwater*
- ~Draw down *aquifers* (case of Ogallala aquifer)
- ~In coastal areas, promote *saltwater intrusion* into freshwater wells
- ~Soil degradation through *Waterlogging & Salinization*

Irrigation Problems

-**Salinization**- when the small amounts of *salts in irrigation water become highly concentrated* on the soil surface through evaporation (salt reaches toxic, impede plant growth)

-**Waterlogging**- when the *soil remains under water for prolonged periods* which impairs root growth because the *roots cannot get oxygen*.

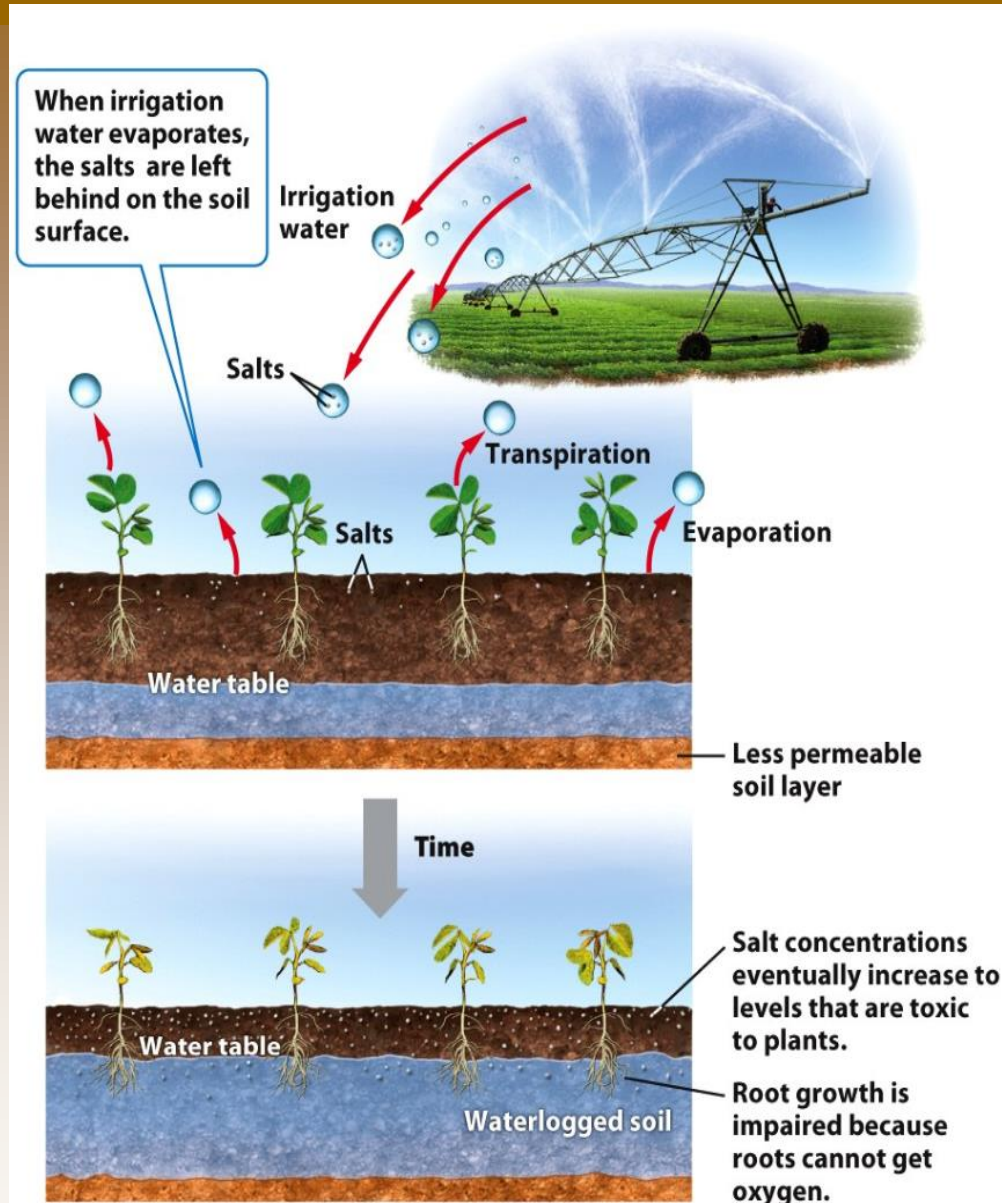


Figure 11.6

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Fertilizers

Nitrogen (leaf growth), phosphorus (rooting system) & potassium (strong stems/faster growth) foster plant growth (what nutrients fertilizers contain)



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- ~Agriculture removes organic matter & nutrients from soil
- Organic fertilizers**- organic matter from plants and animals. Typically made from animal manure that has been allowed to decompose.
- Inorganic fertilizers (synthetic)**- fertilizers that are produced commercially. This is usually done by combusting natural gas, which allows nitrogen from the atmosphere to be fixed and captured in fertilizer.

Monocropping

- Growing a large amount of a **single species of plant.**



~ *Greatly improve* agricultural **productivity and efficiency.**

~ *Environmental degradation* such as **soil erosion** because planted and harvested all at once.

~ More **vulnerable to pest.**

~ **Removes habitat for predators** that might otherwise control pest control

Pesticides

- **Pesticide**- a substance that kills or controls organisms that people consider pests.
 - *Broad-spectrum pesticides* – kill many different types of pests.
 - *Selective pesticides* – narrower range of organisms
 - U.S uses 1/3 of worldwide pesticide use (-1bill lbs. #2), China uses -1.8 tons (-1800bil lbs.- #1), Brazil #3
 - **Insecticide**- target insects
 - **Herbicides**- target plants/weeds
- **Positive:** rapid, relatively easy response to infestation, efficient
- **Negative:** kill/injury unintended target organism, enter groundwater, carcinogen (ingested, inhaled)

Pesticides

- **Persistent**- pesticides that remain in the environment a long time.
- **Nonpersistent**- pesticide that breaks down relatively rapidly, usually in weeks to months.
- **Bioaccumulation**- some pesticides are found to build up over time in the fatty tissues of predators.
 - An example was DDT.
 - When an organism containing the pesticide is eaten, the chemical is transferred to the consumer.
 - This eventually leads to very high pesticide concentrations at high trophic levels.

Pesticides

Dirty Dozen 2022: Produce with the most and least pesticides

<https://www.cnn.com/2022/04/07/health/dirty-dozen-produce-2022-wellness/index.html>

- **Resistance**– pest populations may **evolve resistance to a pesticide over time**. These are said to be *resistant*.
- **Pesticide treadmill**– the **cycle of pesticide development** followed by pest resistance, followed by development of a new pesticide.

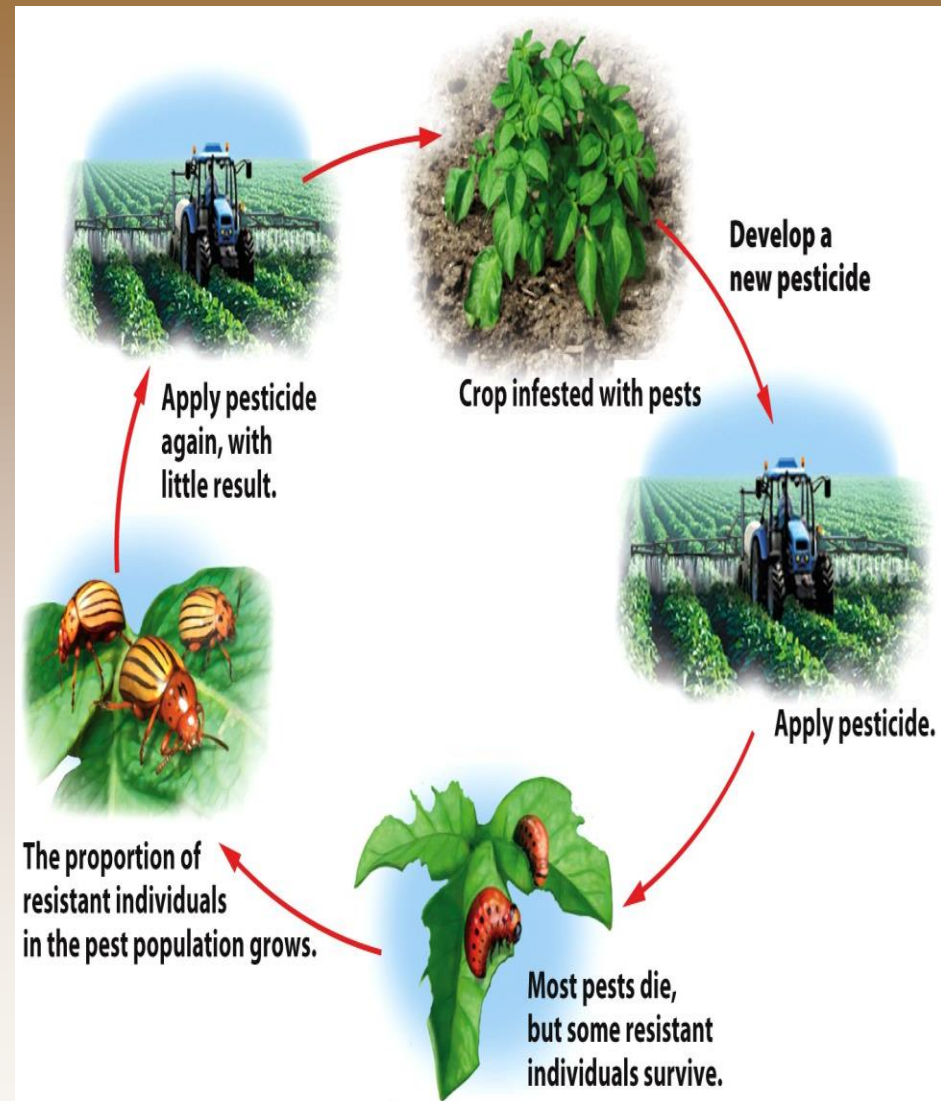


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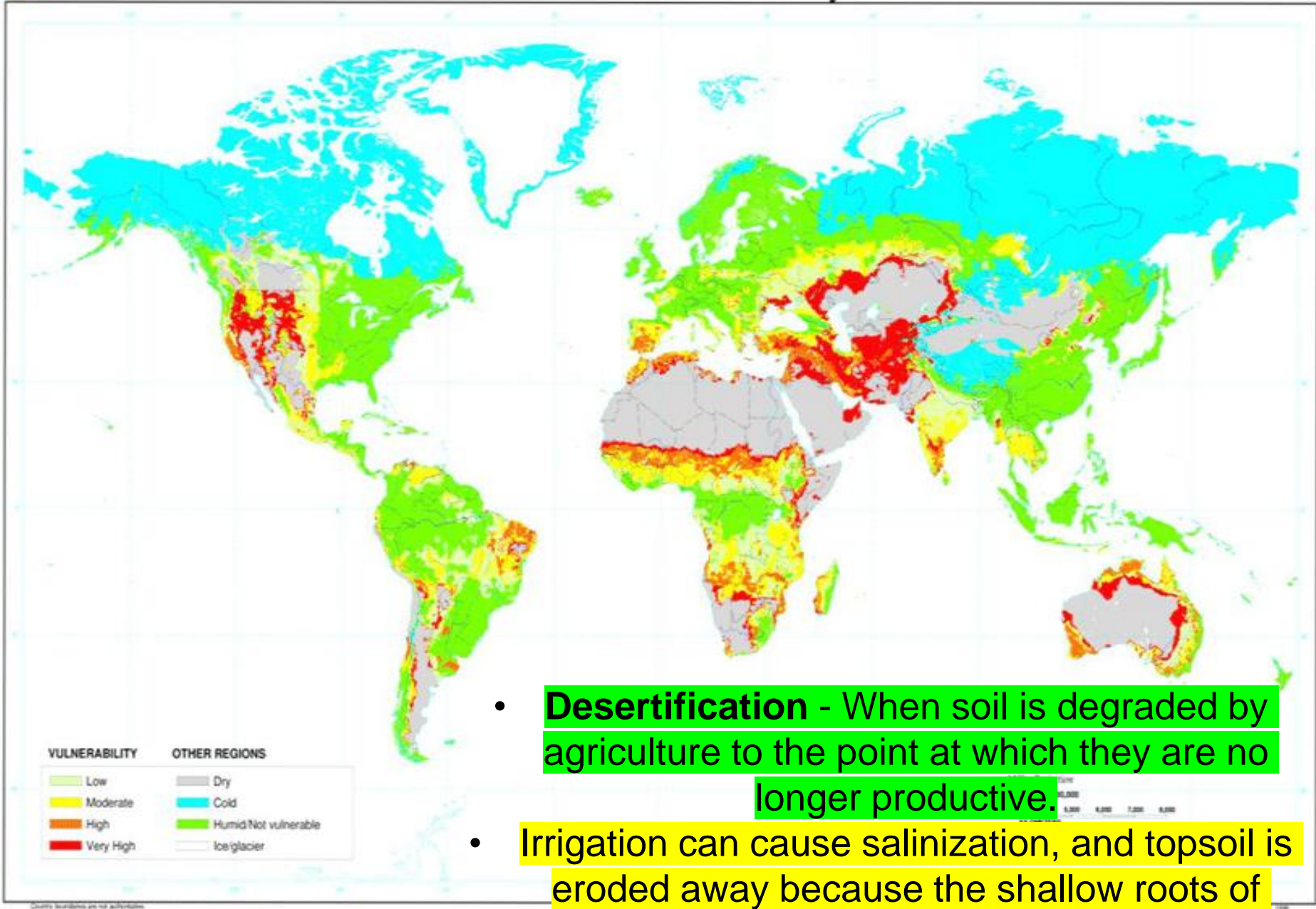
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Farming Methods

- **Conventional agriculture-** *industrial agriculture* where **labor is reduced, and machinery is used.**
- **Traditional farming-** still used in the *developing world* where **human labor is used and not machinery.**
- **Shifting agriculture-** used in areas with nutrient **poor soils.** “*slash-&-burn*” clear-cut vegetation & burning resulting in ash is rich in K^+ , Ca^{2+} , Mg^{2+} which makes soil more fertile
- **Nomadic grazing-** moving herds of **animals to** find productive **feeding grounds** (low productivity).

Desertification Vulnerability



- **Desertification** - When soil is degraded by agriculture to the point at which they are no longer productive.
- Irrigation can cause salinization, and topsoil is eroded away because the shallow roots of annual crops fail to hold in in place.

Sustainable Agriculture

- **Sustainable agriculture**- producing enough food to feed the world's population without destroying the land, polluting the environment, or reducing biodiversity & economic stability for farmers
 - **Crop rotation**- rotating crops species from season to season.

Intercropping- two or more crop species are planted in the same field at the same time (multiple crops/land).



Intercropping



Contour plowing

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- **Contour plowing**- plowing and harvesting parallel to the land to prevent erosion.

- **Agroforestry**- intercropping trees with vegetables.



Agroforestry

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No-till Agriculture

- **Plowing & Tilling** – processes that physically turn the soil upside down and push crop residues under the topsoil, thereby killing weeds & insect pupae.
- **No-till agriculture** helps to stop soil degradation (erosion, reduction in organic matter, increase CO₂) by leaving crop residues in the fields and not tilling the land after each harvest.



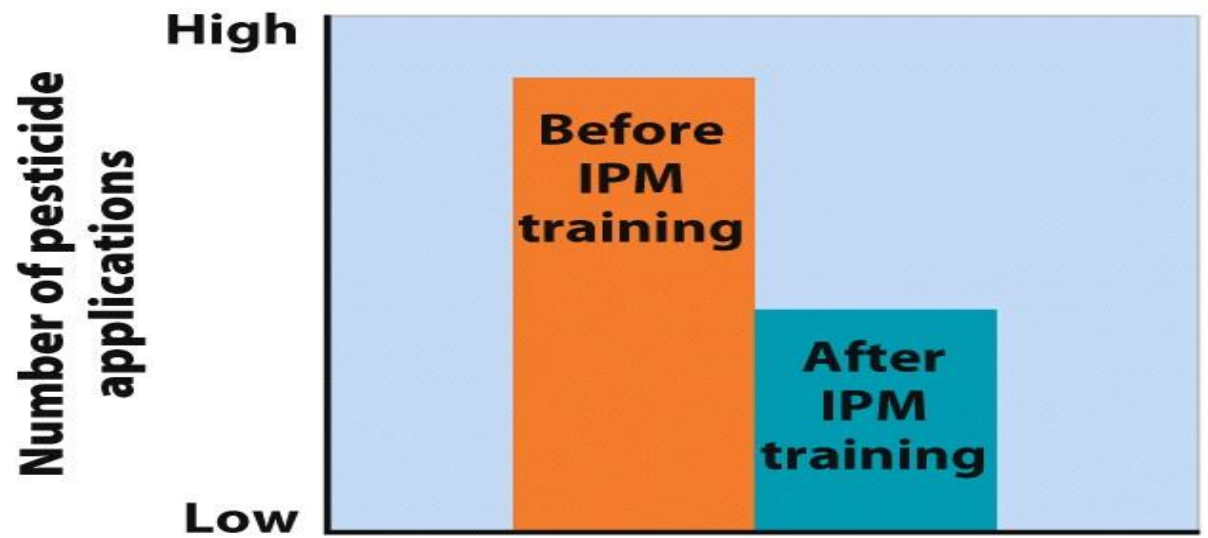
Figure 11.15

Integrated Pest Management (IPM)

- **Integrated pest management**- using a variety of techniques designed to **minimize pesticide inputs**.
 - **Crop rotation** (prevent pest infestations)
 - **Intercropping** (harder for specialized pests to establish themselves)
 - **Planting pest resistant crop varieties** (prevent pest infestations)
 - Creating **habitats for predators (natural control)**
 - Limited **use of pesticides**

 - **Time** spent to learn the pest & crop lifecycle (in field)
 - **Works well in developing nations**, where high-input industrial farming model is not feasible (labor costs are low or lack of resource)

Yield improved because farmers paid more attention to their crops.



(a) Pesticide use



(b) Harvest

Figure 11.17

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Organic Agriculture

- Organic agriculture- production of crops without the use of synthetic pesticides or fertilizers.

BASIC PRINCIPLES:

~use ecological principles & work with natural systems rather than dominating them (nature take its course)

~keep as much organic matter and as many nutrients in the soil and on the farm as possible (healthy soil)

~Avoid use of synthetic fertilizers & pesticides (no chemicals)

~Maintain the soil by increasing soil mass, biological activity, & beneficial chemical properties (healthy soil)

~Reduce the adverse environmental effects of agriculture

Negatives:

~increase more labor costs, but premium price to consumers

~Some alternative pest control methods are not always environmentally friendly.

Ex. propane flamer before planting to prevent weeds to grow on/around crop (carrots)

The Green Revolution

- Transformed agricultural system from a system of small farms relying on human labor and low fossil fuels inputs to a system of large industrial operations with fewer people and more machinery...advancements in technology.
- New management techniques and mechanization as well as the triad of fertilization, irrigation, and improved crop varieties. This has increased food production dramatically.
- Through intensive breeding, developing new strains, use of fertilizers, irrigations, genetically modifying to become resistance...etc

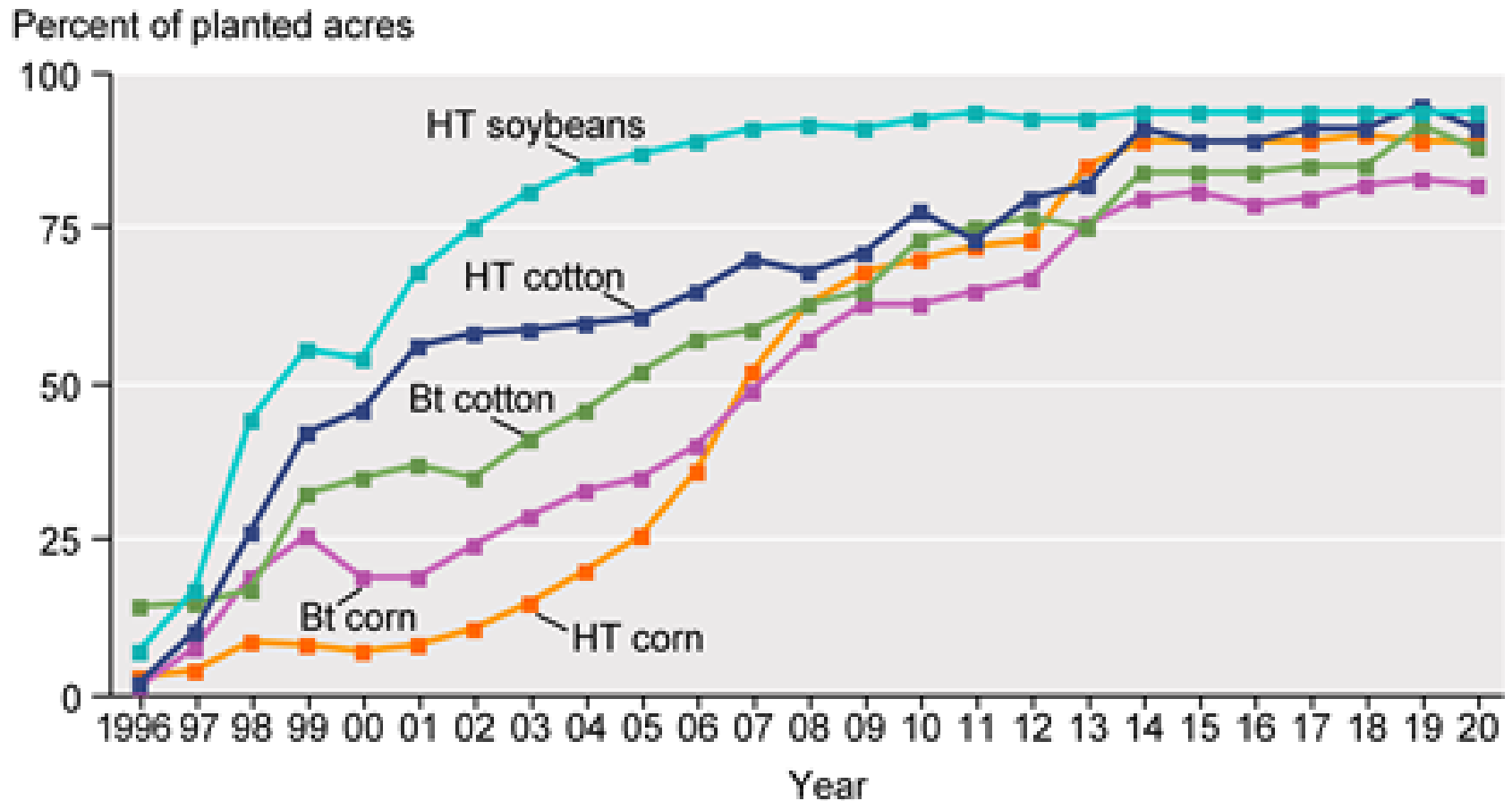
The Next Green Revolution



Genetic Engineering

- Scientists can isolate a specific gene from one organism and transfer it into the genetic material of another (manipulating specific genes...can rapidly produce organism with desirable traits).
- Crop species, have been modified to increase their output of seeds or fruit.
- In 2009, 63% of corn, 91% of soybean, & 71% of cotton planted came from GM seeds.
- In 2022, ~90% of corn planted was GMO corn (89.9 mill acres of corn planted in US). GMO soybeans made up 95% of all soybeans planted, GMO cotton made up 93% of all cotton planted
- **More than 95% of animals used for meat and dairy in the United States eat GMO crops (corn, soy, & alfalfa).**
- **Upwards of 80% of processed foods** on supermarket shelves – from soda to soup, crackers to condiments – contain genetically engineered ingredients

Adoption of genetically engineered crops in the United States, 1996-2020



Note: HT indicates herbicide-tolerant varieties; Bt indicates insect-resistant varieties (containing genes from the soil bacterium *Bacillus thuringiensis*). Data for HT/Bt corn and cotton are not mutually exclusive, as HT and Bt categories include those varieties with overlapping (stacked) HT and Bt traits.

Source: USDA, Economic Research Service using data from the 2002 ERS report, *Adoption of Bioengineered Crops* (AER-810) for the years 1996-99 and National Agricultural Statistics Service, (annual) June Agricultural Survey for the years 2000-20.

WHAT DO THESE CODES MEAN?

Ionizing Irradiation

Electronically Pasteurized

PLU codes that start with a 3: **#3xxxx**

Conventionally Grown

Sprayed with pesticides

PLU codes that start with a 4: **#4xxx**

Precut Produce

Fruits & vegetables

PLU codes that start with a 6: **#6xxx**

GMO & GE

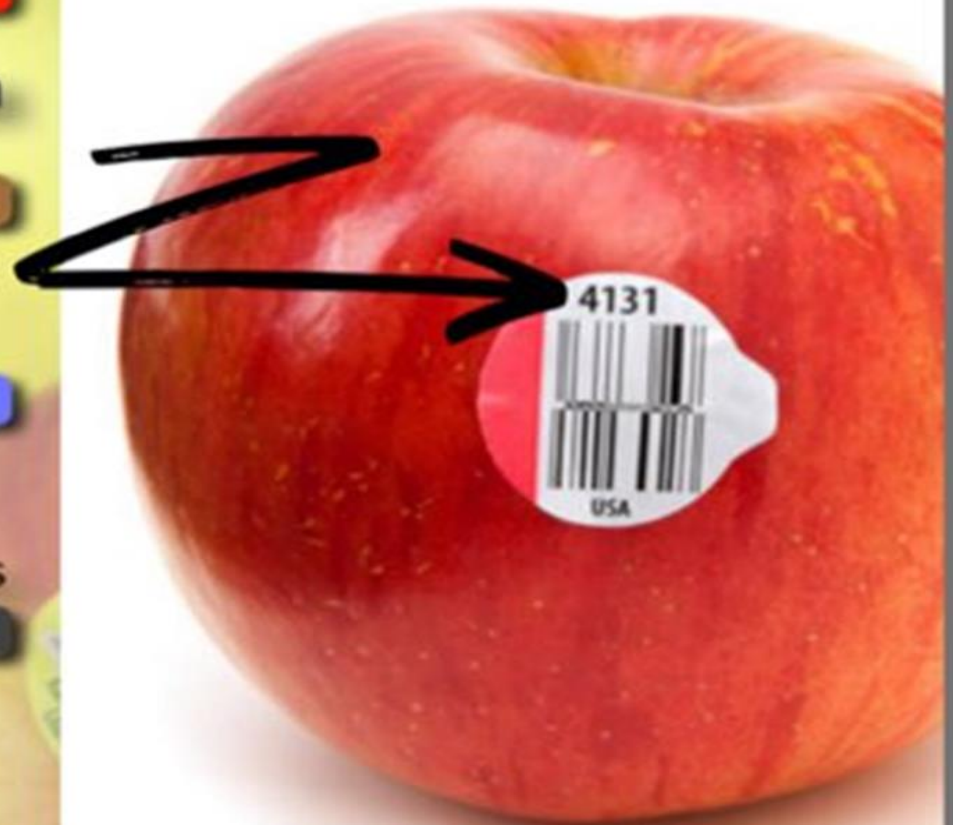
Genetically Modified Organisms

PLU codes that start with a 8: **#8xxxxxx**

Organic

Limits the use of synthetic materials during production

PLU codes that start with a 9: **#9xxxxxx**



FoodSanity.com

Benefits of Genetic Engineering

- **Greater yield** (growing time of species for food production)
- **Greater food quality** -Imbedding more nutrients & vitamins (Golden rice, vitamin A)
- **Reductions** in **pesticide use**
- **Reduction** of **world hunger** by increased food production
- **Changing genetic blueprint** (DNA) of organism (fish gene into a strawberry, cold resistant)
- **Increased profits** (produce pharmaceuticals within other organisms; bacteria, plants or animals)

Concerns about Genetically Modified Organisms

Safety for human consumption

- Long term effects -1994 commercial sale
- Allergic reaction
- Banned chemicals and substances

Effects on biodiversity

- spread of modified genes can eliminate or altered of natural (native) plant varieties
- use of GM seeds is contributing to a loss of genetic diversity among food crops (resistance/kill an entire organism)

Regulation of genetically modified organisms

currently no regulations in the U.S (FDA)