Teaching with the Stars: Agriculture and Water

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About this document

This document outlines the major themes and issues related to Agriculture and Water. Each section is intended to stand alone and may be used to develop curriculum and lesson plans. Content was drawn from multiple sources which are cited in the text and listed at the end of the document.

Introduction

The connection between agriculture and water is immediate: one can discuss very little about agriculture without mentioning water. All agriculture occurs within a watershed or an ecosystem whose geology (subsurface geology and soils), biology (plants and animals), and climate determine the types and amounts of crops that can be grown. The study of agriculture within the context of water resources must consider the entire water cycle: both above ground manifestations of water such as rainfall, absorption, plant uptake, evapotranspiration, runoff, surface water (streams and rivers), and infiltration and underground storage. A dynamic system of ground and surface water cycling and soil moisture retention absorbs and stores heavy rains, maintaining a wide variety of water sources to drive crop production in the absence of rain.

Over the last 100 years, modern agricultural has placed the highest priority on production and has emphasized the use of machines, chemicals, and elaborate processing and distribution systems and markets to maximize profits. These methods have been successful in producing large quantities of food and wealth at the expense of ecological integrity, resulting in soil erosion, ground and surface water contamination, and displacement of our traditional land stewards- the family farmer. New approaches that integrate science and technology with knowledge and respect for local watershed and community health, work with ecosystem processes to protect water resources while supporting abundant agricultural production and healthy, productive agricultural communities.

Overview of Agriculture

Agriculture is a primary industry. Primary industries that produce food, wood, paper, and metals support nearly all other industries. Traditionally agriculture includes grazing, row and non-row crops, forestry, and aquaculture. Historically the foundation of food production is crop cultivation and pastoral herding on rangeland on which climate and soil condition determines stocking rates/carrying capacity of the land. Agriculture led to the rise of civilization because excess or surplus food produced by farming allowed populations to become sedentary, increase and stratify. People had more leisure time to develop culture and technology. Today, there are numerous forms of agriculture that extend from sustainable agriculture to intensive farming. In the United States, for example, much of the livestock production is not in herding but takes place in confined animal feeding operations where thousands of animals are raised in one building. Worldwide, in 2007, one third of the world's workers were in agriculture with 20% of the world's population working 45% of the world's cropland. This has resulted in overproduction, a decrease in the number of farms, and an increase in farm size.

Agricultural Requirements

Agriculture requires a specific range of inputs and conditions to be successful. **Water** is one of the most important factors in agriculture's success. Without water, agriculture, and ultimately, humans would not exist. So all water is important, but it is not all the same. **Water sources** vary and the price, characteristic and quality of water will vary according to the source. Rainfall is the cheapest water source. Rainfall dependent agriculture, which is practicd extensively in Asia and Africa, requires a minimum of 10 inches of annual rainfall without irrigation. Because agriculture requires plentiful rain to grow crops and requires a reduction in rain to facilitate harvests, the timing of the rain is also very important. Of course, we can't always count on nature to deliver the rain at the exact time it is needed. So irrigation has many advantages. If you've ever wondered why we have established agriculture in the desert using irrigation, it's because people have moved to these areas and have worked to establish local food source. In addition there are advantages to growing irrigated crops in desert conditions. Farmers, for example, can easily time water distribution to when plants need it. Arid areas also have fewer insects and disease to manage. The disadvantage, however, is that building and maintaining an irrigation system of canals and pumps is far more expensive than a rain dependent systems. But irrigation can be efficient enough to help farmers produce crops at a rate that covers their costs. And once the irrigation system is in place, it costs significantly less to operate.

Another source of water is groundwater, which must be pumped from the underground aquifers. Groundwater quality can be on the salty side and have high mineral content which can harm soils. Some aquifers that provide groundwater like the Ogallala in the Midwest are being depleted for agriculture and other purposes. In other words, we are using the water faster than it can be replenished. Replenishment of groundwater is known as recharge. Aquifers recharge at different rates. On the one hand, the Ogalalla aquifer recharges very slowly. The Edwards Aquifer in Central Texas, on the other hand, recharges very quickly.

Water can also be obtained through desalination, which is very expensive. Desalination removes salt from the water from either ocean water or salty groundwater using high amounts of energy. The desalination process produces a salty brine that must be disposed of safely Desalination may become a viable source of water for agriculture as water battles between large cities and agriculture intensify. Water battles have a tendency to intensify because water is bought and sold in markets. As cities grow along with their demand for water, the owners of the water find it more profitable to sell water to the cities than to an agricultural interest.

Appropriate temperatures. Food crops require temperatures that support healthy growth and harvests. Worldwide 1/5 of the earth's surface is too cold for food production. Cold temperatures do not support biodegradation and microbial activity which is important for crop production. This is the case with the arctic which has abundant organic matter but insufficient biodegradation to support generation of nutrients in a form that plants can use.

Topography. Of course it is much more difficult to grow food on the side of a mountain than on a flat field. This is because moisture runs off of mountains very quickly, removing fertile soils. In Asia and in other parts of the world, terracing is an adaptive measure for hilly conditions. Terracing involves leveling the side of a hill in stair step fashion in order to create flat growing plots that can hold soil and retain moisture.

Soils and soil condition- Fertile soils support high production unless the temperatures are too cold. Soils that lack nutrients and moisture can be fortified by integrating crop production and livestock operations. These integrated systems grow feed for the animals and apply animal waste to the depleted soils, which acts as fertilizer. This helps agricultural operations maintain healthy vegetative cover that is important for healthy soil. This is because the root systems of plants channel water into the soil, aerate the soil, and the plant overall shades the ground to reduce moisture loss through evaporation.

The Importance of Soils

Fertile soils are a source of wealth and energy for the cultures that cultivate them: they can produce abundant and nutritious plant and animal life. One of the most important components of healthy soil is **Organic Matter**. Organic matter provides a stabilizing buffer against sudden climate or other changes. For organic matter to decay, it requires moisture, warm temperatures of at least 45 degrees F and oxygen. Left over materials from crop harvesting, such as stalks, can be plowed under to put nutrients into the soil that can act as a source of. This fuel decays and is processed through microbial activity and gives off heat, keeping the soil warm in the cooler months lengthening the growing season.

Rotating crops can provide important nutrients to soils and ultimately to future plantings. For example, planting clover before corn can deliver nitrogen that corn needs, as clover deposits nitrogen (through fixation processes). If soils are low in organic matter, the protein content of plants can be reduced. Without organic matter soil becomes compacted. This constricts root growth because the roots don't get enough air or room to grow, and microbial activity and water storage can also be negatively impacted, which kills the roots and the plant. Compact soils also mean that fertilizers are not absorbed well which may cause them to be released into the environment and not be available to the plant. **Soil fertility** requires several key nutrients: **Nitrogen**- which stimulates growth; **Phosphorous**- which is an essential mineral in plants, and; **Potassium** which helps plants stay healthy and fight disease. Healthy soils are also rich in microbes, earthworms, macroinvertibrates (microscopic bugs) and fungi.

The United States Department of Agriculture has extensive educational resources on soils. These are located at: Soil Quality: http://soils.usda.gov/sqi/

The **Web Soil Survey** provides access to the largest natural resource information system in the world. NRCS has soil maps and data available online for more than 95 percent of the nation's counties and anticipates having 100 percent in the near future. Access the Web Soil Survey at:

Web Soil Survey: http://websoilsurvey.nrcs.usda.gov/app/

Agricultural products

Major agricultural products in the world include:

- Food, fiber, fuels, and raw materials
- Biofuels- biodiesel, ethanol
- Biopharmaceuticals
- Bioplastics
- Pharmaceuticals

- Cereals, vegetables, (grocery store foods)
- Fibers- cotton, wool, hemp, silk, flax
- Lumber, bamboo
- Resins
- Cut flowers, nursery plans, tropical fish, birds

Agricultural Systems
There are several key factors that drive agricultural decision making. The first is **the size of land holding**. Large farms may specialize in one product such as corn or wheat. A small farm might raise a variety of products including animals. Who owns the farm is also important. **Farm ownership** may be private or corporate. This could determine how much capital is available to invest in new technology and equipment. How **resources are used** on the farm can vary as well and determine the **value of the land resources for agriculture**. If the land is hilly and the soils lack fertility, the landowner may chose grazing over row cropping. The type of labor and level of capital available for investment will also determine how the farm operation can implement new technologies and respond to market demand.

There are numerous types of **Agricultural Systems**. Some examples include **ecological systems** that provide for basic human needs, are located where higher production levels are not possible, are predominant where culture is traditional, averse to change, isolated, reliant on natural products, and sparsely populated. **Gatherers such as** hunting and fishing cultures are typically located in coastal areas and in the continental interiors. Other systems include: **Nomadic grazing, shifting cultivation** (a subsistence system that consists of forest clearing followed by production, and reversion to jungle or forest); **subsistence systems** consisting of small, 2-3 acre farms; **commercial systems** that rely on markets and suppliers for seed, chemicals, machines and labor; **tropical and subtropical plantations** that produce rubber, bananas, tea, sugar, and cotton; **midl-altitude grain farming, vegetable and fruit culture** that includes the pineapple operations in Hawaii and citrus in Florida; **mixed crop and livestock** of the eastern US and Midwest which support operations that are smaller than the large grain farmers; **dairy farms** of the northwestern US and southern part of the Lakes states, Pacific NW, California and Texas; **livestock ranching** in the arid and semi-arid western US where there is enough moisture for grass but not for crops. Here, livestock are shipped for fattening to areas with surplus grain, such as the Midwest. Finally there are community owned/operated lands in Mexico known as **ejidos**.

Zones of Agriculture
There are three major global zones that support agriculture. The **Tropics** are characterized by long and warm days and nights that increase plant respiration and utilization of plant sugars, making it very difficult to grow most grain crops. This area receives heavy rainfall but the soils are very nutrient deficient.

In the **northern climates such as the Arctic and sub-Arctic**, natural growth is limited by the availability of decaying organic matter because soil and air temperatures are low. The virtual absence of darkness during the growing season, however, promotes large harvests if nutrients are applied. Note: this area is not susceptible to drought.

In the **Temperate Zone** , between the tropic and the Arctic, planting strategies are based on planting early in order to capture the most sunlight. Fertilizing in early Spring stimulates early growth, so crops can be harvested early and often more than once per growing season. The temperate zone has wide ranging annual rainfall, 22" is a typical minimum rainfall level at which regional plants are able to thrive (it takes about 22" of rain between May and September to make a corn crop). Water storage in the soils and groundwater helps ensure water is available when needed during the growing season. Soil moisture retention is extremely important and is achieved with mulch and by the plants themselves through shading.

Agricultural development patterns

Historically, agriculture generally started at a very small scale with low, diffuse population. The frontier on which agriculture took hold may have had visible but difficult to access water resources. Canals created for irrigation allowed agriculture to expand so people could settle instead of farming nomadically in reaction to changes in the weather and water availability. As population expanded and transportation, water, and sewage systems were developed, efforts turned to increasing production through use of chemicals and machines. The intensification of animal production and chemical use has caused water quality degradation, and the need to upgrade public water distribution.

Agricultural risks

Agriculture can be risky business as it can fall victim to a variety of natural phenomenon that include: freezes, high winds, heavy rains and floods, droughts (Dust Bowl of the 1930's), and pest infestations (the Hopper Year of 1874). Some of these natural disasters such as extreme pest infestations have intensified pesticide use, resulting in river, lake, and aquifer contamination. Additional water contamination is often caused by the application of nutrients and fertilizers as soils become less productive from repeated use and poor soil management practices. The resulting public health concerns have prompted calls for the development of organic farming methods and have accelerated efforts to upgrade public drinking water treatment systems. **Desertification** is an increasing problem in modern agriculture. Hot, humid climates are prone to desertification because resources are often more intensely for longer periods of time.. This results in overgrazing, vegetation loss, erosion and soil loss.

Modern Agriculture

Modern agriculture, in general, produces larger yields, i.e. more crops than agricultural systems using less intensive, traditional methods. Modern agriculture achieves higher plant and animal yields in several ways. **Selective breeding** can produce hybrid corn which substantially out produces traditional varieties. Chemical fertilizers add nutrients to the soil and can dramatically in crease yields. The **proper application of fertilizers** ensures more of the expensive chemical reaches the plant resulting in a production benefit versus being washed away into the streams and groundwater, wasting money and polluting the environment. **Machinery** reduces harvesting and planting times, allowing for greater harvests to be produced with fewer labor costs. **The use of sub marginal lands- i.e. infertile areas** is avoided through scientific soil testing. **Pest and weed controls** help to ensure predictable and abundant harvests, by reducing crop losses. Modern agricultural practices that lead to lower yields include: over-**planting** that causes erosion and the loss of vegetative cover, and **nutrient depletion** in soils from loss of organic matter.

Keys to Agricultural Success

The **Keys to Agricultural Success** are based on an interrelated network of interdependent factors. One factor that contributes to agricultural success is the ***environment***:

> "Agriculture is highly sensitive to climate variability and weather extremes, such as droughts, floods and severe storms. The forces that shape our climate are also critical to farm productivity. Human activity has already changed atmospheric characteristics such as temperature, rainfall, levels of carbon dioxide (CO_2) and ground level ozone. The scientific community expects such trends to continue. While food production may benefit from a warmer climate, the increased potential for droughts, floods and heat waves will pose challenges for farmers. Additionally, the enduring changes in climate, water supply and soil moisture could make it less feasible to continue crop production in certain regions.
>
> The Intergovernmental Panel on Climate Change (IPCC, 2007) concluded:
>
> Recent studies indicate that increased frequency of heat stress, droughts and floods negatively affect crop yields and livestock beyond the impacts of mean climate change, creating the possibility for surprises, with

impacts that are larger, and occurring earlier, than predicted using changes in mean variables alone. This is especially the case for subsistence sectors at low latitudes. Climate variability and change also modify the risks of fires, pest and pathogen outbreak, negatively affecting food, fiber and forestry.

Climate Factors
Several factors directly connect climate change and agricultural productivity:

- Average temperature increase
- Change in rainfall amount and patterns
- Rising atmospheric concentrations of CO2
- Pollution levels such as tropospheric ozone
- Change in climatic variability and extreme events"

Source: http://www.epa.gov/climatechange/effects/agriculture.html

Climate, soils, and natural resources such as natural gas, oil, and wind are important for energy production that can boost farm production.

A second factor is ***crop selection***. Crops need to match environmental conditions. Farmers do not always plant the most appropriate crops, and instead, plant what's familiar to them or brings the highest profit when harvests are successful. An example of this is the settlement of northern Kansas. Settlers attempted to plant corn, which was very successful in the east where seasonal rain was consistent. In Kansas, corn was not successful, due primarily to the dry summer climate. Later, it was discovered that sorghum was a more reliable crop due to it is drought and wind tolerance.

A third factor is ***technology***, which can mimic optimal and consistent environmental conditions through the use of machines. Examples of technology mimicing nature include: , the disk plow, which was designed to leave a small portion of the surface material such as straw on top of the ground to retain soil moisture; harvesting equipment that leaves plant material in place to retain soils and contibute nutrients; pumps for irrigation, canals and irrigation ditches that allow farmers to irrigate crops when they need the water most. .WWII technology, when transferred to the farm, increased the horsepower of the farmers' machines, thereby increasing production capability. More powerful machines were adapted for farm use along with more widespread use of chemicals such as fertilizers, pesticides and herbicides. The increase in use of technology resulted in agricultural specialization, in which farmers focused on the production of a few crops such as wheat and barley. **Specialization** toward single or few crop production was tied to higher production costs due to reliance on expensive equipment and larger fields or production areas. Specialization also led to the expansion of the food processing industry and farms began to perform fewer of the processes necessary to bring products to market. One downside to specialization is the proliferation of mono-cultures which have lower resilience and an increased disease vulnerability, lower genetic diversity, and lower resistance to pest infestations.

Another factor related to technology is the development of farming techniques that help mitigate changing climatic conditions and retain soil moisture. These techniques have been practiced almost since the beginning of agriculutre yet are once again being emphasized for their environmental benefits. These techniques include fallow farming to retain soil moisture, crop rotation, leaving residue in the field, terracing, and contour farming.

Recent Technological Highlights
There are several **Technological highpoints** worth noting that led to a boom in agriculture during the 1900s. The most significant development was the Tractor - King of Agricultural Technology. By the 1920's the tractor and

associated farm equipment had reduced the man-hours required to produce one acre of wheat from 60 hours in 1820 to only 4 hours. **Fertilizer and better plant varieties and animal breeds** also helped produce higher yields. Between 1930 and 1970 new corn varieties helped farmers produce 20% more corn on 25% fewer acres. Not only could farmers plant more, but more of the plants remained healthyCrops were even engineered to mature at a uniform rate so harvests produced a more abundant and uniform product. Crops were also developed to be more compatible with harvesting machines so they would not bruise when harvested by the machines. On the livestock side of agriculture, animals were bred to increase yield by producing more products (meat, milk, wool) with lower nutritional requirements. For example, hogs were bred to be larger, with leaner muscle and sheep were bred to produce more wool and higher quality meat.

In the agricultural world, **chemicals** are considered as much of a technological tool as the tractor. Modern agricultural technology developed effective insect, disease, and weed controls. Dramatic insect infestations such as the introduction of the Mexican boll weevil in 1892 nearly destroyed the Southern economy. Other insect infestations included: cattle tick, corn borer, Japanese beetle, viruses, wheat rust, nematodes, Mediterranean fruit fly and many others. WHAT CHEMICALS WERE DEVELOPED TO COMBAT THESE? Weed controls were necessary to eliminate plants that competed for soil nutrients, water and space. Some problem plants include Johnson grass and kudzu.

Finally, a significant shift in technological emphasis in the latter part of the 20th century has been toward conservation OF WHAT? SOIL?. Conservation practices seek to minimize environmental impacts and in some cases optimize environmental benefits of agricultural practices. These practices include: better tillage and conservation practices; contour plowing; establishing row crops at right angle to slopes; grassland drainage ways; crop rotation,stubble mulching, wildlife corridors, buffer zones, multiple crop plantings to reduce pests, and rotational and complementary planting to increase soil nutrient levels.

Animal Agriculture

The benefits of domesticated animals. When humans domesticated animals such as goats, cows and sheep, they ensured themselves a reliable source of food, fuel and clothing. Animals provide us with a variety of benefits that include: protein from meat, eggs, and milk; fuel from dung which includes biogas production; clothing material such as wool, skins, leather, and feathers; drugs such as insulin; animal power (mostly in the developing countries); resources such as manure that support sustainability incentives to grow crops for forage as part of crop rotation; use of crop residue for feed and bedding. Traditionally, crops and livestock were raised together on the same farm which is increasingly viewed as a more sustainable approach to agriculture than modern agricultural methods which tend to specialize and separate crop and animal production.

Modern livestock production (including cows, pigs, goats and sheep) has separated animal production from crop production by concentrating animals in one area, known as confined ranching operations and factory farms, creating large volumes of waste that can pollute the air, as well as surface and groundwater. The resulting **specialization** has increased environmental impacts, raising overall costs of production when these operations are forced to comply with environmental regulations.. A concern of the public in recent years has been the use of feed additives in modern livestock production. Additives are given to animals to aid digestion, and prevent illness and disease. Digestion issues stem from using lower quality feed ingredients not typically used by livestock, including blood and bone meal. Incidences of decreased animal health are due to the confinement of large amounts of animals in small spaces, as well as exposure to larger amounts of animal wastes and excretions. The most controversial additives include antibiotics, hormones, and preservatives. Other additives that are not as controversial are enzymes, flavoring agents, herbs, and probiotics.

Animals that are well-suited to factory farming must be easy to manage and efficiently produce high volumes of protein. Chickens have many attributes that are conducive to industrialization. They reproduce through egg-hatching that can occur on a set schedule. They grow rapidly and have the ability to efficiently convert grain into meat They reproduce very quickly, are easy to handle and require less space than large livestock. Processing can be automated which eliminates high labor costs. Chicken meat is considered healthier than red meat and the chicken industry can easily be exported to virtually any location in the world. GIVE EXAMPLES OF OTHERS?

People's concerns about industrialization of livestock production include cruelty to animals the loss of small and local farming operations, the reduction in nutrient content, as well as the increased presence of antibiotics and other chemicals in animal products, and finally the high volume, high concentration of waste that creates environmental problems.. A sustainable future for factory farming would address these concerns and include maximizing output per acre while retiring excess land into ecologically beneficial conditions such as forests, native grasslands, and wildlife habitat that promote healthy watersheds.

Articles on livestock production and the associated environmental and economic issues can be found at:

http://www.fao.org/ag/magazine/0612sp1.htm

http://www.news.cornell.edu/releases/aug97/livestock.hrs.html

http://en.wikipedia.org/wiki/Environmental_effects_of_meat_production

Agriculture and Water

The connection between agriculture and water is strongest at the watershed level. Watersheds not only drain water to a common point or source, but they also support many key components of the water cycle. Healthy watersheds support healthy ecosystems that provide numerous services known as **ecosystem services**. Healthy forests and vegetative cover regulate atmospheric gases, help control floods by slowing the flow of water down, provide aesthetics, wildlife habitat, recreation and hunting opportunities, and facilitate water storage and waste treatment/pollution control. Agriculture's on-going challenge is to maintain watershed function and the benefits that agriculture and society accrue from it while maximizing profits and minimizing short term watershed exploitation. In this sense, farmers can be viewed as providing many ecosystem services by preserving the integrity of the natural ecosystem.

> "Humankind benefits from a multitude of resources and processes that are supplied by natural ecosystems. Collectively, these benefits are known as **ecosystem services** and include products like clean drinking water and processes such as the decomposition of wastes."
>
> Source: http://en.wikipedia.org/wiki/Ecosystem_services

This represents a shift in perspective from the resource exploitation of the early 1900's (which only focused on maximizing yields) to a more sustainable approach today that is optimizing production, minimizing ecological damage and maximizing quality of life.

Farmers need predictable sources of water to grow plentiful, fresh food. For an agricultural area to be successful it must have several important characteristics. As indicated above, regular rainfall is critical. In the absence of this, irrigation systems are needed to deliver good quality water that has low salt content. The cost of transporting water to the field must also be affordable. So it also helps if the topography is flat or the water flows downhill to the production site, minimizing the energy costs of water delivery. In general, the cost of water is included in a weighted total cost that is compared against agricultural profits. Farmers can mitigate unpredictable conditions by diversifying crops, such as growing a mix of corn and wheat, producing eggs, and growing garden produce.

Agricultural demand for water is driven by a number of factors, the most important of which is price. Several factors drive water prices. First to be considered is transportation cost, which is a function of distance and elevation. Aquifer depth is also a factor- how far down one must drill to access adequate supplies of high quality water. The second factor is demand. In a drought when water is scarce, water prices may increase significantly. A third factor is water treatment. Low quality water may need to be treated or diluted with clean water (at a substantial cost to the farmer) before it can be used in the fields or given to livestock. A fourth factor that can increase the price of water is deferring the cost of developing new water sources. By paying slightly higher rates while water is plentiful, water customers can set aside resources for development of future sources, thereby reducing the future cost of water. While water price affects the amount of water consumed, there are other factors in the economic equation. The price, quantity and type of crops produced may allow a farmer to afford to use more expensive water knowing he will cover costs once he sells his product. Good soil and climate may allow more efficient use of water.

Quality of the water

Water quality is nearly as important to a farmer as water quantity. Salty irrigation water can degrade fields over time because water evaporation leaves salts behind. An example of this is the Colorado River water in the West. Near the California coast over-use of wells can draw in seawater, destroying water wells. Other sources of contamination include septic systems, waste lagoons, and industry. Agriculture can also affect water quality. For example, in the Rio Grande Valley residential and agricultural water conveyance systems were once joined which exposed the public to high levels of agricultural chemicals. Air borne chemicals, spills, illicit discharges, and other nonpoint source pollutants can contaminate surface waters that people rely on for recreation and drinking water. A common source of pollution from agriculture is nitrogen and phosphorous which promote algal growth and eutrophication, and disrupt the natural ecological balance that supports aquatic life. Nitrates and additives in animal feed can pollute groundwater when dung is spread on fields for fertilizer and as a soil amender.

Irrigation

Irrigation mitigates climatic conditions by providing water during periods of irregular rainfall. Irrigation systems are usually established where a reliable and consistent source of water flows through otherwise fertile land. These rivers originate from mountain snow melt or are fed by artesian springs. In the mid and western US, early irrigation used canals were funded through private investment. Construction was very costly and few companies made money. Irrigation canals came with advantages and disadvantages. The advantages were that they increased property values. Second they encouraged farmers to plant crops atypical of the climate. Third, they attracted settlers and additional investment in the community. The downside to canals include up to 50% losses of water to evaporation and conveyance. Canals are also more easily contaminated due to exposure to residential, industrial and other sources of nonpoint source pollution. In the 1960s, the expanded use of water soluble chemicals and aerial applications caused a contamination boom in the Lower Rio Grande. Later irrigation systems used powerful pumps to tap groundwater from deep aquifers such as the Ogallala. Wide use of irrigation systems are rapidly depleting the Ogallala, which replenishes itself so slowly that pumping water from this aquifer is considered water mining (withdrawing water faster than it can be replenished naturally) .

Water Weight Chart

http://www.swfwmd.state.fl.us/publications/files/waterweb-fla-agriculture.pdf

Popular Fruits	Food Weight (grams)	Water Weight (grams)	Percent Water
Apple	138	116	84
Blueberries	145	123	85
Orange	140	122	87
Strawberries	149	136	91
Watermelon	160	146	91

Popular Vegetables	Food Weight (grams)	Water Weight (grams)	Percent Water
Broccoli	44	40	91
Carrots	72	63	88
Cucumber	52	50	96
Pepper	50	46	92
Tomato	123	115	94

Also – may want to use:

Liters of Water	Gallons of Water	Product
16,000	4226	1 kg/2.2 lb beef
1350	356	1 kg/2.2 lb wheat
1000	264	1 liter/.26 gal milk
70	18.5	1 apple
3900	1030	1 kg/2.2 chicken
2700	713	1 cotton shirt
80	21	$1 industrial product

Watershed health and livestock grazing

A watershed is an area of land that has a common drainage, In other words, water runs off to the same network of rivers and streams. Watersheds capture, clean and store water. Watersheds are able to do this by maintaining sufficient vegetative cover and root systems that provide channels for water to infiltrate into the ground. Grazing can damage vegetative systems resulting in erosion, less water infiltration, and invasion of exotic plants with high water needs. To be sustainable, grazing management must support and enhance beneficial watershed conditions. When watersheds become denuded through overgrazing and lose their natural function, eliminating grazing altogether may not be the best solution because proper land management that restores the complementary relationship between plants and animals can help watersheds recover.

Riparian areas

Riparian Areas, which are located at the edge of streams, protect water quality by providing a buffer between uplands and streams. Over grazing in the riparian areas can impair watershed function by destroying this buffering function To prevent this, ranchers can fence off these areas preventing animals from using them. Wetlands are similar to riparian areas because they are fertile areas with plentiful forage for grazing. They are very sensitive to environmental damage though, and can place domestic animals in competition with wild and endangered species.

Rangeland health

Rangeland health can be maintained with properly managed livestock grazing. Historically, larger herds were a symbol of wealth (versus animal size or weight). Overstocking brought about large scale desertification (most notably in the Middle East and other areas of the world). People in these areas failed to respect the fact that animals and grasses co-evolved. Plants provide animals food, and the animals return nutrients in the form of dung and urine to the plants and till them into the earth through hoof action. Animals were also instrumental in reducing the buildup of dried plant residue which provided fuel for fires. Man's desire to suppress fire has also damaged watersheds because fire reduces unwanted and dead plants and helps maintain the productivity of the range.

Alternative Agriculture

Alternative agriculture recognizes that healthy, profitable agriculture and a healthy environment can go hand-in-hand. New practices, such as hydroponics have emerged in response to the environmentally damaging and costly high yield practices of the 19th and 20th centuries. These practices emphasize: conservation of soil, energy, and biological resources; the relevance of the family farm; crop rotation that reduces weeds, disease, and the need for chemical use, and increases soil nutrients; integrated pest management (IPM) and other biological controls to reduce pesticide use and water pollution; animal health maintenance through disease prevention which can reduce use of antibiotics and other drugs whose use the public has come to distrust; targeted use of chemicals through remote sensing to identify plant moisture needs (facilitates precise irrigation) and the use of global positioning systems (GPS) that use satellites to precisely apply chemicals; retirement of the plow which breaks up and loosens the naturally established soil structure; conservation tillage and limited use of chemicals. See the section titled "Sustainable Agriculture" for more information about alternative agriculture.

Hydroponics

Hydroponics is an alternative form of agriculture that does not use soils. The term hydroponics is formed from two words, hydro meaning water, and ponics meaning labor- working water. Hydroponics raises and harvests plants in a water medium instead of soil. The operator adjusts the nutrients in the water to provide the plants with all the nutrition they need to be productive. There are several advantages to growing food hydroponically. Hydroponic systems are completely closed allowing the "farmer" to control virtually all inputs including amount of water, nutrient levels, and air and light conditions. Because these systems are enclosed, they can produce food in the harshest of conditions: in deserts and Polar Regions, in cities, where soils are poor or contaminated, or even in outer space. Another advantage is that most of the labor costs are eliminated. There is no pruning, tilling or weeding, etc. Hydroponic systems are also very productive which allows high production where arable land is scarce. Environmental contamination is minimized and water is conserved because it is recycled.

Hydroponics has its disadvantages as well. It is very expensive to establish hydroponic infrastructure and a successful operation calls for highly trained workers. If diseases show up, they can spread very quickly to the entire crop, which is one reason by the plants must be tended to every day.

Agricultural History of the United States

Source: Hurt, Douglas, R. 2002. *American Agriculture: A Brief History.* West Lafayette: Purdue University Press.

American Colonial Agriculture
Colonial Agriculture quickly moved beyond subsistence farming and into domestic and international commercial markets. Agriculture expanded most rapidly in the north because land was cheap, towns and markets were close by, and there was a strong artisan population to develop tools and purchase products from the farm. Unlike the more heavily populated North, the South struggled with high labor costs and little to no technology which prevented the expansion of commercial crops until the introduction of slavery and a social caste system. The dominance of the wealthy landowners drove smaller farmers west.

Independence
The revolutionary war (as is the case with most wars) increased demand for farm products, driving up prices and benefiting farmers. Wars and crop failures in Europe also maintained high demand and allowed early American farmers to thrive. A strong commercial agricultural economy was becoming firmly established as commercial farmers gained access to technology, agricultural science, transportation, and towns and markets. The high productivity of commercial agriculture quickly depleted soils driving farmers west in search of new, fertile land.

Antebellum years (1815-1860)
The Antebellum period (meaning before the war) is known for the growth of commercial agriculture. During this period agriculture overproduced and created surpluses. The federal government began funding development of irrigation canals and railroads to expand markets so farmers could discharge their surpluses. There was a shift at this time from the use of hand tools to horse drawn plows. Slavery expanded bringing large profits to a few large farms, marginalizing small farmers in the south. Farmers spent considerable time clearing land. Hogs and corn became a common livestock/grain production model. Farmers in the Midwest focused on increasing production while farmers in the northeast focused on more specialized products to sell in nearby towns.

Civil War
Southern agriculture was devastated during the Civil War as the Union Army burned fields and destroyed equipment and infrastructure. The North, on the other hand, suffered little damage and instead accelerated development of machinery and technology to compensate for a labor shortage created by army recruitment. Women stepped up, playing a growing role in running farm equipment. New processing technology, used by the Bordon company to condense and can milk, was introduced to service the army. New rail lines that brought more grain to the markets and property improvements in the North increased farm value.

Gilded Age (1865-1900)
Farm culture grew increasingly commercial as farmers chose to specialize in various farm products. The higher cost of specialization, which includes specialized equipment and the need for efficient transportation, caused farmers to incur more debt. They became tied to bankers and increasingly dependent on railroads. The Homestead Act offered free land, fomenting a land rush, the construction of the transcontinental railway, and the expansion of mono-cropping in the Midwest. Self-sufficiency became a suspect value of the farming culture, implying a resistance to change and technological progress. Share cropping dominated the south which remained impoverished with poor diets, poor health and few medical resources, and an inefficient economic system that kept farmers in poverty.

The Golden Age (1909-1920)
Leading up to the Golden Age, the federal government funded irrigation projects in 16 western states strengthening the foundation for agricultural expansion. Wars again drove demand and farming became very profitable. The

concept of parity emerged during this time, which established in farm policy the idea that farmer's income should at least be equal to that of other Americans. The Golden Age realized high prices and high demand for farm produce. This success helped agriculture diversify across the country. The Great Plains became more mechanized and industrialized. The far west specialized in vegetables and fruit orchards. The Pacific Northwest specialized in wheat; dairies in the northeast; corn and livestock in the Midwest, and; cotton and tobacco in the south. Agricultural science began to make an impact as George Washington Carver, in an effort to help southern farmers expand their markets and lift themselves from poverty, developed 300 products from peanuts and 100 uses for the sweet potato. Veterinary medicine also emerged as a science-based profession. Golden Age prosperity allowed farmers to expand into the Great Plains and invest in machinery to expand wheat production. One of the most significant developments was the internal combustion tractor which grew in number from 5 in 1900 to 17,000 in 1917. The tractor and the combine reduced harvest time and lowered the risk of loss from weather damage. Improper management of wheat fields left little ground cover when wheat was not planted. These factors combined with low rainfall and steady winds dried out the ground and caused the Dust Bowl of 1932.

Troubled (yet productive) Years (1930-1950)
The most significant developments during this period were in science, technology and government policy. World War II brought a respite from low prices as the government urged farmers to increase production to "feed" the war effort. Post war surpluses precipitated a market crash and government action to adopt the Agricultural Adjustment Act (AAA) which established price supports that would preserve parity (income at the same level as other Americans) for farmers. Technological developments funded through the war were used to produce more powerful farm machines such as tractors, trucks, combines, and cotton pickers. More powerful chemicals in the form of pesticides, herbicides and fertilizers became available along with new seed and animal hybrids. The result was increased production along with rising production costs. An exodus of farmers ensued as farm size increased through consolidation and the political power of the farming culture began to wane.

Uncertain times (1950-2000)
The number of farms was in decline as farmers faced high production costs and low prices. By 1990 farmers make up only 1.9% of the total US population, with most farmers reliant on some source of non-farming income. By 2000 only 1% of farmers lived full time on the farm. To be successful, farmers now needed capital, more land, better management skills, and government price supports. The cost of entering agriculture for young people became prohibitive and many chose not to enter into farming or to continue operating family farms. Many acres of land held by family farmers is sold and converted to suburban residential uses. New powerful diesel pumps were brought to the high plains to introduce center pivot irrigation for grain production. Aggressive pumping of the Ogallala Aquifer is a form of water mining since the recharge rate for the Ogallala is significantly slower than the rate at which water is being pumped out of the aquifer. New markets such as corn-based ethanol were created to absorb over production while draw down of the Ogallala remains a troublesome issue.

The 21st Century
Biotechnology, agricultural science and engineering are playing a more significant role in agriculture. Genetically modified foods have been developed to boost production and resistance to a variety of agricultural hazards, but they remain controversial because the potential ecological and health impacts are not fully understood.

The Agricultural (Green) Revolution of the 20th Century

Agriculture changed very little between biblical times and the beginning of the 20th century. Changes in the 20th century exceeded all of the agricultural changes in the last 10,000 years. The Green Revolution of the 20th century drastically increased yields of plants and meat. The agricultural advances responsible for this increase included: plant breeding, pesticides, fertilizers, technological improvements, selective animal breeding and intensive animal farming. In 1910, 70 minutes of labor produced $1 of farm income. By 1980 this was reduced to 4 minutes. In 1910 it took 81 minutes to produce a bushel of corn. Today it takes about 2 minutes. These efficiencies increased income and production which today must meet the needs of a population that is 3.5 times larger than in 1900. The Green Revolution made food cheaper. In 1910 we spent about 25% of our income on food. Today we spend about 14.5%. We also export food that feeds millions, in some cases, eliminating disease and improving physical well-being. The Green Revolution is not without downsides: increased ecological damage, concerns about animal cruelty, and human health effects of antibiotics, growth hormones, and other chemicals used in meat and dairy production. In 1910 30% of the American population worked in Agriculture. Today this percentage has been reduced to 1.5%.

Major Transformations

Within a very short period of time, a single generation, several major developments permanently and dramatically transformed agriculture. These developments began with **mechanical power**, followed by **chemical products**, followed by **biological products** and systems followed by improvements **in communication**, development of new sources of **power namely electricity**, and the introduction of **pneumatic tires**. The disciplines of farming also became very sophisticated requiring the farmer to have a good command of finance, economics, and business management, reflecting **changes in culture and education**. Each of these transformations had many dimensions to them.

Mechanical

The most significant transformation was from the horse or mule to the tractor and the buggy to the automobile. In 1776 James Watt produced the steam engine and in 1892 John Froelich developed the gasoline powered tractor. It took agriculture 100 years to adopt many mechanical advances because farmers were conservative and did not want to take the risk of investing in new equipment; they were too poor to buy the equipment; they were too uneducated; or they did not want to take risks with new technology. The process of technology adoption was facilitated not only by increases in power from 10hp to the 100 hp tractor, but also with reductions in weight that resolved issues of large machines bogging down in the fields. With these new machines and their associated farm implements, corn production grew from 21 to 121 bushels of corn per acre as a national average. The introduction of these machines also illustrates the interconnectedness of the various components of agriculture. The mechanical developments had to be accompanied by biological developments. For example, when the farmer transitioned from the Husking hook to the gas powered corn combine, these new harvesters required development of new plants that would stand stiff and erect to accommodate the mechanical harvesting process.

Other developments saved the farmer time and money and brought welcomed conveniences to the very challenging and rugged conditions on the farm. These included central plumbing which freed the farmer and his family from carrying water from a well to the house or to his animals. Twenty for hour a day electricity broke the farmers dependence on kerosene as a source of light and heat. As roads became paved, **Pneumatic tires** increased the speed and traction of the farm equipment and facilitated development of a very efficient harvesting and marketing systems.

Chemical

Prior to the 1900's, farming still used the same basic technology used for thousands of years. In other words, if a farmer from 2000 BC were transported to the late 1800's he would likely know how to use most of the farm tools. As the Agricultural Revolution unfolded, however, "magical" chemicals were developed. The hoe, which was used for millennia to weed the fields, gave way to the use of herbicide chemicals. At first, little regard was given to the environmental effects of these chemicals. The gains in production were the sole focus. Over time, however, it was observed that lead arsenate, DDT, and other pesticides and herbicides persisted in the environment with unintended consequences- randomly killing plants and animals and making humans sick. The Agricultural Revolution responded by developing safer biodegradable chemicals. Optimizing production while protecting human and environmental health remains an on-going challenge for agriculture.

Biological

At the turn of the 20th century, the world was beginning to absorb the implications of Charles Darwin's Origin of Species. Genetic manipulation was considered more mythology than science. By the end of the 20th century though, bioengineering had made its way fully into agricultural production. The hybridization experiments in 1865 gave way to the use of growth hormones and genetically modified products that can resist designer herbicides. The use of low cost labor to control weeds manually was replaced by highly advanced techniques for weed control and plant management that require extensive resources to implement. These high capital requirements facilitated the rise of the corporate farm. The integrity of low technology foods of the past was rarely in question. There was a high level of trust in American food products. With increased technological inputs, however, consumers have begun to raise questions about food safety. In recent years, there has been growing controversy and resistance to genetically modified foods (GMO) which are banned in Europe.

In the case of animal production, farmers' attachment to tradition persisted prior to the 1900's until science and technology began to dominate agricultural decision making. In the past, farmers produced traditional animal breeds. Science showed farmers how to implement selective breeding to create stronger and more productive breeds of plants and animals. The ultimate focus on profit (based on weighing the cost of inputs versus production and price) also drove the development of new types of farming such as aquaculture. Overfishing has reduced fish stocks from their abundance in the wilds of the 1800's forcing fisherman further out to sea (resulting in higher fuel and labor costs). Aquaculture was developed to produce fish and other seafood on farms at a predictable cost and in close proximity to markets.

Communication

At the turn of the 20th century, information traveled through the postal service or through interaction at the local markets or trading hubs. The high cost of sending information slowly by mail has been transformed to the vastly reduced cost of sending information quickly electronically. The information needs of farmers today are much greater than in the past. Farmers typically got all the information they needed directly from their fields, local markets and trading hubs. Today farmers need information about international markets, performance and price of machinery, politicians, plant and animal nutrition, and the weather. The centralized trading hubs no longer exist in the same form as in the past. Today they are largely decentralized trading centers that send price information over the internet through electronic trading systems. The internet and other information technologies are also changing and improving crop management practices. Today the farmer does not have to make estimates about fertilizer or irrigations water application based simply on experience. The farmer can adjust fertilizer and water applications scientifically through remote sensing equipment and global positioning systems (GPS).

Culture and Education

The transformations in culture and education have been monumental and have transformed the character of the rural community. Prior to the 20th century, rural children received very little schooling. Their school was usually a one room school-house and most children did not attend college. Today the rural community has access to large, consolidated school districts in which students can graduate and continue their education through the land grant college system. Farmers have long perceived themselves as independent and self reliant. Today the farmer is part of a centralized decision making system that directs many aspects of agricultural production. This system is linked to worldwide markets and information systems. In addition it may be largely industrialized or owned by a corporation instead of family owned. Finally it may be is heavily dependent on capital investment versus labor (usually far above what one farmer can afford, given the costs of machines and chemicals).

This system has raised income for most full time farmers from poverty levels in the early 1900's (farmers made 71% less income than other Americans) to income levels equal or slightly above (about 5% higher) the average American today. The number of farmers though has decreased significantly. High costs have forced many farmers to leave the business or farm only part time, resulting in the fall of farmers from a majority class in the United States to a minority. The Agriculture Revolution has experienced another significant transition as it has assimilated the benefits and consequences of technology and science. The dominant drive for profits at the expense of resource conservation in the early 1900's has inflicted sufficient environmental and cultural damage that the cost of not practicing conservation is now fully recognized and is a growing concern for all agricultural practices.

Historical Foundations of the Agricultural Revolution

- 1793 Eli Whitney invents the cotton gin which separated cotton from the seed. One cotton gin could do the work of 50 farm hands
- 1807 Robert Fulton invents the steamboat
- 1816 C. Hoxie invents the threshing machine
- 1825 the Erie Canal opens
- 1834 Cyrus McCormick produces the reaper which replaced hand-cut grain
- 1837 John Deere invents the steel plow- dirt did not stick to it as readily
- 1859 petroleum discovered in Pennsylvania
- 1859 JS Fawkes produces the steam driven plow
- 1869 the transcontinental railroad is completed increasing access to markets and increasing farmer income
- 1903 powered flight
- Early 1900's George Washington Carver develops products from sweet potatoes, peanuts, pecans

Food Processing

Historically humans concerns regarding food have been mostly centered on food supply - having enough food to eat. Today food quality or nutritional value is the overriding concern. A good example of the early awareness of food quality and nutrition is the global shipping industry's problems with scurvy, a debilitating and deadly vitamin C deficiency that plagued crews of merchant ships. Today the primary purpose of our food production and processing system is to turn food that is not ready for human consumption into a consumable product while ensuring food safety and nutritional quality. Food processing also keeps prices low by sustaining a consistent food supply. The alternative is a highly seasonal selection of food or even a greater percentage of spoiled foods in our markets and refrigerators. Maintaining consistently low prices is important since food comprises about 16% of the US family budget. Quality of processed foods has more recently come under scrutiny with concerns about the nutritional value of highly processed foods, "junk" foods, and fast-food. .

Food Safety

Most food poisoning occurs from improper food handling at home or in restaurants. Food contamination from other sources is kept to a minimum because the food processing industry works to ensure food safety by preventing food contamination The food processing industry works to minimize incidents of food poisoning by focusing primarily on the manipulation of bacterial growth factors such as bacteria, yeasts and molds. When we smell rotting or spoiled food we are smelling substances that are excreted by bacteria that are causing the food to spoil. Bacteria and other microorganism not only spoil food, but they can also beneficially enhance food. For example, microorganisms are used to manufacture certain foods such as cheese, yogurt, and bread. Whether the industry is attempting to cultivate the beneficial uses of bacteria or it is attempting to control its harmful effects, the food processing industry must take several factors into account in order to control the growth of microorganisms. Moisture and temperature are key factors in the growth of microorganisms. The optimal growth temperature for microorganisms is 30-34 degrees C. Moisture aids bacterial growth which is why the industry controls moisture through drying fruit, freezing vegetables, or salting foods. Chemicals such as acids (vinegar) and inert gases can also be added to foods to inhibit microorganism growth. Canning eliminates all microbes.

Food Properties

The food processing industry focuses on controlling various food properties to ensure optimal nutrition, taste and texture when products arrive in your kitchen. Basic food properties are known as proximate compounds which are protein, carbohydrates, fats, minerals, and water content. Processors work with both macronutrients, which are proteins, fats, and carbohydrates, and micronutrients which are vitamins and minerals. The food processor must know the quantities of proximate compounds in various raw foods in order to determine the optimal processing strategy. For example, raw milk has a variable fat content that will direct the processing procedure for making butter, and other milk products. Knowledge of the raw food's moisture content will determine the stability of the food when stored. Foods with low moisture content tend to be more stable in storage. Processors must also comply with numerous food laws which require that food processing maintain various levels of proximate compounds, such as a certain percent of fat in butter, maximum water content, or minimum protein levels.

Food processing and nutrition

Food processing methods are designed to convert the maximum amount of nutrients in the raw materials into food for human consumption and minimize nutrient loss during food processing. In general, it is very difficult to maintain farm fresh nutrition unless the food is purchased and consumed at the local level. Processing, therefore, usually destroys some level of nutrition, which may be unavoidable if one considers harvesting the most basic form of food processing. Nutrients are lost through various food processing techniques that are, in fact, beneficial to the consumer. Nutrients may be physically removed during the wheat grinding process. They may be deactivated by heat, light, or oxygen exposure. Essentially processing manages a variety of nutritional trade-offs in which the process of improving raw foods may destroy some nutritional properties. For example, milk pasteurization kills both harmful pathogens and nutritional vitamin C. Baking can destroy some nutrients but increase the digestibility of remaining nutrients. Since all processing results in some nutrient loss, foods may be fortified after processing. In general it is best to select a varied diet to ensure one is getting a full array of beneficial nutrients.

Food processing techniques
The most basic or primary food processing techniques are used to prepare fresh produce for market. These include washing, trimming, and sorting. Secondary processing techniques are used by bakeries and cheese factories to process raw materials that are not immediately available for human consumption. Examples include flower, sugar, cooking oil, yeast, etc. that are processed into baked goods. The next level of processing technique is the tertiary level and such techniques are generally employed by companies to produce packaged and ready to eat foods such as canned stew, or instant coffee.

Food additives
Food additives have been developed to protect shelf life, preserve nutrition, enhance the "appeal" of various foods (such as color, artificial flavors, and sweeteners), and ensure product stability. Additives are used to ensure chocolate milk stays mixed, they prevent salt from caking, enable cakes to rise predictably, prevent mold from growing on bread, and add nutrients to cereal. Additives known as preservatives are used in meats, jams, jellies, bread, cheese, and many processed foods to prevent growth of bacteria and mold.

Food labeling
Food labeling serves number of purposes.

> Food packages generally have two types of consumer information required by the Food and Drug Administration (FDA). The **Nutrition Facts** section defines a serving size and describes the weights of macronutrients (fat, carbohydrate, protein) in a serving and the percentages that these macronutrients represent of the daily Recommended Dietary Allowance (RDA) for a 2000-Calorie diet. Additional information may be provided for specific minerals, vitamins, or other components of interest such as cholesterol. The second type of consumer information is the **List of Ingredients** which contains the basic components of the product in order of decreasing weight. Since the basic components must be listed, products containing ingredients consisting of several components must list the components in parentheses. A breakfast cereal containing crystallized ginger must list it as "crystallized ginger (ginger root, sugar)". Manufacturers sometimes add explanatory notes about an ingredient, e.g., "BHT (a preservative)".
>
> Source: http://www.scientificpsychic.com/fitness/labels.html

Labeling helps consumers control their diet, first by listing ingredients that are potential allergens and secondly by allowing people to track their nutrient, fat, protein, carbohydrate and caloric intake.

Labeling serves as a tracking system when food contamination is reported. Food labels contain a wealth of useful information including the product name, quantity, manufacturer, storage conditions, shelf life, and a list of food manufacturing ingredients in order of quantity.

Food packaging materials
There are three types of packaging, primary, secondary and tertiary. Primary packaging comes in direct contact with the food. Secondary packaging includes boxes that contain product stored in primary packaging. Tertiary packaging will surround boxes and is used in shipping large quantities of food. A good example of tertiary packaging is pallet wrap. Typical packaging materials include paper, glass, metal and plastics.

Food packaging keeps food stable until we open it at home. Without packaging food would spoil more quickly and would most likely need to be purchased more often and in smaller quantities. Most foods found at the store would be seasonal and would more likely be contaminated with insects, microorganisms, or pollutants. Packaging can make food more convenient, e.g. bottled water. It protects food from a variety of contamination sources: environmental (dirt, moisture, light) and biological (microorganisms and pests). Packaging material is widely variable because it has to serve a variety of purposes. Some packaging is designed to keep oxygen and water in contact with the product. A good example is beef. Oxygen helps the meat retain its red color. Some packaging is designed to keep oxygen out, as in the case of cereal. Packaging, like product labeling, is also an information source which allows manufacturers to market the product when a company representative can't be in the store. This allows the grocery store to be a self-service industry where the customer chooses their own food products. Finally packaging can reduce product waste as in the case of the single serving ketchup packets. Although these characteristics of packaging benefit the companies, they can result in overuse of packaging which is discarded and dumped in landfills.

Farm Production and Food Processing

There are a variety of factors that influence what a farmer will produce and therefore the selection of the processing method. These factors include product yield, insect resistance, compatibility with soils and climate, product composition, and effectiveness in utilizing fertilizers and feed. The farmer also needs to consider that there is more than one variety or use for some products (wheat or milk) which will determine how the product is processed. For example: potatoes for the table are processed differently than potatoes for french fries. Wheat that is good for pasta makes poor bread. Some cow's milk is higher in fat and is more suited for making butter, - while other breeds produce greater quantities of lower fat milk. An understanding of the raw food product and how it will be processed is critical to managing the planting and harvesting process, the costs associated with this and the eventual price the farmer will receive for the raw food product that he or she produces. A quick look at the harvesting process for tomatoes further clarifies this. Tomatoes make it to the grocery store in a variety of forms. Table or salad tomatoes are different from the tomatoes used to make ketchup. Ketchup tomatoes are tougher, and some are bred to be square so they can easily be packaged and can withstand rougher treatment by harvesting machines. This allows the ketchup tomato farmer to harvest a lot more tomatoes in a shorter period of time than the table tomato farmer.

Environmentally friendly food processing

A complete understanding of the environmental impact of food processing requires a Life Cycle Assessment (LCA) or an assessment of the production process from start to finish. The purpose of an LCA is to identify which step in the process has the greatest environmental impact. Several factors are considered when conducting and LCA: raw materials, processes, transportation, manufacturing, use, and waste management. The field of environmentally friendly food processing is relatively new and requires a lot of information at a wide variety of input levels, from energy and water used in growing crops to transportation, sanitation, packaging and storing food.

Agricultural Economics

Just like any other business, farmers must bring in more money by selling products than they pay out in the cost of production. One of the most significant challenges for the farmer is producing enough crop to cover his costs and make a profit while not overproducing. Over production results in crop surpluses that can drive down prices, resulting in lower profits. Economic factors outside the farmer's control can also influence demand and consequently price. In general, ***wars*** increase demand for agricultural products. WWII created a strong demand for wheat and farmers responded by increasing production. When the war ended there was an oversupply of wheat and the market threatened to crash, prompting the government to intervene in stabilizing prices. These surpluses, such as surplus wheat, were absorbed through initiatives to reduce ***world hunger***. These initiatives expanded markets, increasing demand and price. ***Energy prices*** can also affect a farmer's rate of production. If water is expensive, a farmer may limit pumping duration to cut costs, which results in smaller crop yields and reduced profits, but at a lower cost to the farmer.

Agribusiness and Industrial Agriculture

Industrial Agriculture is both energy and capital intensive which impacts the environment, the economy and society. In general, it moves people away from the land, reducing the number of family farms; increases farm size and trades goods within significantly larger markets. Growth in urban slums has accompanied the reduction in farm population. Increasing emigration to urban areas results in higher demands for urban water supplies, which further fragments the rural watershed (when reservoirs are built) and places farmers' water needs in competition with powerful urban interests.

Industrialization of agriculture has also increased the distance that our food must travel to reach our plate. Today our food travels roughly 1500 miles from its source to our table, a 50% increase from 1979. This additional distance requires the heavy use of processing and packaging which also use more energy and deliver less nutritional food. Large landfills are required to dispose of the trash resulting from discarded packaging. Incineration can produce metals and toxins that can pollute ground and surface water. **Mono-cropping**, the practice of growing a single crop to maximize profit, reduces biodiversity which increases the crop's susceptibility to pests and blight. In other words, there is a higher risk of massive crop loss because the farmer has placed all his "eggs" in one basket. This is why Industrial Agriculture uses high amounts of chemicals - to reduce risk of crop failure. (Sustainable Agriculture on the other hand, cultivates ecological health to reduce risk - see section on Sustainable Agriculture)

As agribusiness has developed over the last century, it has integrated markets and services in order to eliminate competition and maximize profits. It has given farmers a guaranteed market and good prices but has removed the farmer from decisions about what and when to plant. Agribusiness concentrates animals and their wastes which has raised concerns about animal cruelty and environmental concerns about both strong odors (that create "dead zones" around farm factories, i.e. no one wants to live nearby) and waste discharge into ground and surface water, in violation of water pollution laws. Agribusiness is also known to have hired illegal immigrants who settle for low wages and poor working conditions as meat packers, egg producers, and field workers. Ownership is also an issue. Foreign ownership of US operations, corporate mergers, and the purchase of seed and implement companies by pharmaceutical and chemical companies has drawn attention to the power and accountability of agribusiness. This power has threatened family farms and created the largest publically held company (Cargill which enjoyed $50 billion in profits in 2002).

An elaborate international trading system has developed to protect agribusiness' interests. The General Agreement on Tariffs and Trade (GATT) is an effort to prevent individual countries from passing laws that impede free trade, even if they are designed to ensure food and environmental safety. The globalization of our food markets is displacing local food production resulting in less food security, poorer nutritional quality, greater levels of pollution, concentrated animal waste, and lower biodiversity.

Biotechnology

Biotechnology was developed with the idea that specific plants could be designed to thrive under various environmental conditions or could be modified to increase yield, nutritional level, etc. For example, strains of drought resistant grains have been developed and staple crops have been bio-engineered to include additional nutrients. The idea that biotechnology could reduce farming costs and the use of chemicals has attracted the agriculture industry to biotechnology, as has the notion that engineering crops to be more nutritious can combat starvation and malnutrition in developing nations Biotechnology has produced a variety of plants intended to benefit the industry. These include: drought resistant wheat and soybeans, herbicide resistant wheat and soybeans, cotton that can resist caterpillars, and corn that repels army worms. The biotech industry has also developed bacterial sprays to lower the plant's freezing point, growth hormones to increase animal weight gain with less feed, and genetic splicing and transformation to improve the starch, oil, and protein content of corn.

Biotech challenges

Biotech changes the nature of life. It decreases biodiversity and increases corporate control over our food supply. Farmers who produce biotech crops must overcome several challenges. Genetically modified (GMO) corn must be stored separately from regular corn to maintain its price and to ensure that it is not blended with non-GMO corn. European prohibition of GMO products has raised concerns among produce about market stability. Another concern is that while farmers bear most of the costs and risk of growing GMO crops, the chemical and seed companies are virtually guaranteed profits. The processing industry has also weighed in with its concern over reductions in business due to the increased size of individual animals, which translates into fewer animals to process and therefore fewer profits.

The legacy of farm chemicals

While agribusinesses use of farm chemicals such as DDT has improved production and yields, their use has also polluted ground and surface water, threatened and sometimes damaged the health of farmers and farm workers, and their adhesive properties have raised concerns that they may remain on foods that consumers purchase. These impacts have reduced the economic advantages of corporate farming. Agribusiness with its abundant resources and expertise, however, has the ability to invest in technological solutions that address these issues.

Agriculture and the Role of Government

In 1900 approximately 7% of the Gross National Product (GNP) went to government. At the end of the 20th century that percentage had increased to 31% , reflecting the expanded role of government in agricultural decision-making, from price supports to land management.

United States Department of Agriculture (USDA)
The USDA is the leading agricultural agency in the United States. The USDA has four major goals:

- Assist rural communities to create prosperity so they are self-sustaining, re-populating, and economically thriving;
- Ensure our national forests and private working lands are conserved, restored, and made more resilient to climate change, while enhancing our water resources;
- Help America promote agricultural production and biotechnology exports as America works to increase food security; and
- Ensure that all of America's children have access to safe, nutritious, and balanced meals.

Source: http://www.ocfo.usda.gov/usdasp/sp2010/sp2010.pdf

The USDA experienced a decline in its power during the 1990s. It had become the 4th largest government agency and its failure to adequately control chemical applications and ensure food safety precipitated efforts to involve other agencies in regulating different aspects of agriculture. Pesticide regulation was transferred to the US Environmental Protection Agency and the Food and Drug Administration assumed a more prominent role in food inspection. The USDA was also criticized for discriminatory lending practices that failed to provide equal opportunities for African-American farmers to acquire loans.

Natural Resource Conservation Service (NRCS)

Originally established by Congress in 1935 as the Soil Conservation Service (SCS), NRCS has expanded to become a conservation leader for all natural resources, ensuring private lands are conserved, restored, and more resilient to environmental challenges, like climate change.

Seventy percent of the land in the United States is privately owned, making stewardship by private landowners absolutely critical to the health of our Nation's environment.

NRCS works with landowners through conservation planning and assistance designed to benefit the soil, water, air, plants, and animals that result in productive lands and healthy ecosystems.

Science and technology are critical to good conservation. NRCS experts from many disciplines come together to help landowners conserve natural resources in efficient, smart and sustainable ways. Whether developed in a laboratory or on the land, NRCS science and technology helps landowners make the right decisions for every natural resource. NRCS succeeds through partnerships, working closely with individual farmers and ranchers, landowners, local conservation districts, government agencies, Tribes, Earth Team volunteers and many other people and groups that care about the quality of America's natural resources.

Source: http://www.nrcs.usda.gov/about/

International Trade and Global Food Markets

At the beginning of the 20th century European agriculture was struggling. At the same time, America was at the beginning of its Agricultural Revolution which allowed it to respond with increased production to meet European demand and the demand created by World War I. When WWI ended and European agriculture recovered, the US experienced a market crash. Conditions for a repeat of this cycle were in place during WWII but government intervention helped cultivate new export markets. The trend in exports has transitioned from traditional foods such as rice, potatoes, grain and oilseeds to meats, fruits and consumer ready goods. Rising income in the US changed demand for imports from rubber, coffee and sugar in the 1900's to fruits, vegetables, coffee, grain, and meat in the 1990s. Higher incomes also demanded new tastes and new food experiences, which resulted in the importation of new ingredients from Mexico, Italy, Greece, and China.

In 1900 the primary export market was Europe which received 85% of US exports. By 1998 Europe received far less, around 19%, with Asia receiving 45%, Latin America 18%, and Japan alone (our #1 export county) receiving 18% of US exports. The diversification of exports was triggered by WWII and a 1970 global food shortage. In the 1980s incomes were on the rise in Asia and Latin America which drove the expansion of these markets. Our export markets are highly competitive because there are so many food sources in the world. In the case of genetically modified foods, the stability of US exports is threatened by the perception that US food is not safe or healthy.

World population is growing rapidly and it will be a challenge to feed everyone. Population growth has placed tremendous stress on natural resources, denuded our forests, eroded our land, and filled our cities with displaced people. Hope in effectively meeting demand and addressing our ecological challenges rests in science and technology. Efforts to ensure that we have strong international trading partners involve internationally encouraging the improvements the US experienced through the Agricultural Revolution of the 20th century. These initiatives include: educating foreigners at our land grant colleges; financing international research and development; locating agricultural centers in foreign countries that use modern farming methods and equipment. The technological advancements that will help us meet the challenges of the 21st century include:

- Advances in the use of the computer chip
- Upgrading protein content in cereal grains with biotechnology
- Soil management that allows poor soils to be farmed
- Biological control of disease and insects
- Long range weather forecasting
- Greater use of satellites
- Using biotechnology to fix nitrogen to minimize fertilizer use
- Desalination
- Hydroponics
- Environmental controls
- Food sterilization
- More accountability on the part of the corporate farm
- Use of microbes to produce food for livestock

Mad Cow Disease
Outbreaks of Mad Cow Disease (Bovine Spongiform Encephalopathy- BSE) impact international agricultural markets and threaten human health. The issue that is central to BSE contamination is the agricultural industry's on-going effort to balance profit and public health. Outbreaks of BSE in the latter half of the 20th century rippled through the ruminant industry with wide ranging economic impacts measured in both short term losses of livestock and long-term costs of implementing more robust food labeling programs. Food labeling and inspection remains one of the more significant issues in International Food Trade because it speeds food contamination investigations, establishes a safety program that is visible to consumers (instills confidence), and enhances the stability of markets.

Mad Cow Disease Defined. BSE is a disease that attacks the central nervous system of ruminants and creates holes or cavities in the brain similar in appearance to a sponge. BSE is linked to human disease of the central nervous system - Creutzfeldt-Jacob disease (vCJD), which manifests itself similarly. Human symptoms are dementia, insomnia, and ataxia. From 1995-2000 124 cases were reported in England; six cases in France; Ireland, Italy and US reported one case each. BSE is linked to the use of feed that is contaminated with animal material that contains BSE. The risks to travelers are 1 in 10 billion in Great Britain where the highest incidents of contamination have occurred. This suggests that the risk is lower elsewhere.

US Cattle Industry. Cattle production is the single largest segment of US Agriculture. In 1999 there were 50 million animals in the US with a value of $31 billion ($52 billion in consumer sales of beef and dairy or about 69.6 pounds per year per person). This constituted 40% of total agricultural production. The 1999 export market leaders included Japan ($1.4 billion), Mexico ($454 million), Korea ($331 million), and Canada ($273 million).

BSE History. There are two key events in recent history of BSE contamination. In 1980 the first BSE contaminated cow was diagnosed in Great Britain. This incident wiped out Great Britain's beef industry because numerous cows had to be destroyed. In 2003 Canada announced one contaminated cow, and the United States Department of Agriculture (USDA) responded by blocking import of all ruminants from the farm where the disease originated.

Effects on International trade. At the same time Canada announced the 2003 contamination, Japan required US to prove it was not exporting Canadian beef. As indicated above, Japan is a leading consumer of American beef and the #1 importer of American pork. In 2001 and 2002 Japan claimed 36% of US beef exports. In order to protect American livestock from a Japanese ban, the US banned live cattle imports from Canada to the US. In Europe BSE contamination caused a 20-30% decline in domestic beef sales.

Emergence of Country of Origin Labeling (COOL). COOL applied to beef export labeling and helped speed investigation of contamination. COOL helped to quickly isolate and quarantine suspected problems, keeping quarantines to a minimum. In addition, it helped reduce overreaction and public fears that previously shut down markets.

Beyond COOL. USDA and other organizations like the World Trade Organization, worked to develop and implement emergency inspection programs such as brain testing for cows that behave suspiciously and pushed for a national animal ID system to trace products through all stages of production. Types of labeling include traditional branding, ear tags, and modern computer chips. These developments have resulted in an expanded role for the federal food safety agencies. The role of the World Trade Organization has also grown as European governments have attempted to ban US animal products produced with growth hormones. WTO has sustained the European hormone ban and continues to arbitrate disputes between US and Europe regarding the scientific validity of the hormone ban and assessment of economic damages. Efforts have increased to institute COOL for fruits and vegetables, but this is viewed as high cost for small farms and fish producers. The high cost estimate is $1.97

billion which is distributed among multiple sectors of the international food industry, including: producers (2 million) - $1 billion; handlers (100,000) - $340 million, and; retailers (31,000) - $628 million. Food safety advocates feel the benefits of COOL outweigh the costs.

Preventing BSE contamination. Preventing BSE contamination entails increasing BSE surveillance and aggressive culling of sick animals. Bans on high risk materials (such ruminant protein in feed) and excluding animals over 30 months old from production are all effective industry practices. Consumers can protect themselves by either avoiding beef altogether, or by selecting solid pieces of meat versus burgers and sausage. Exposure risk in the US remains extremely low.

Sustainable Agriculture

The underlying principles of sustainable agriculture are different from industrial agriculture. Sustainable farms are considered ecosystems that should mimic the natural nutrient cycling and conservation of organic matter of the surrounding natural system. Ecosystems consist of a dynamic web of relationships among plants and trees, herbivores, predators, disease organisms, weeds, etc. in which organisms respond to each other. Mid-western farms, for example, can mimic the nutrient cycling of the perennial grasslands by incorporating herbivores, carnivores, omnivores, natural climatic features, and prairie fires. In response to concerns about chemical use and impacts, sustainable agriculture has developed non-chemical approaches. These include the use of natural fertilizer (manure, compost), crop rotation, soil conservation, and no till practices.

Local, sustainable food production requires fewer inputs than industrial agriculture. To control pests, for example, it uses plant diversity instead of chemicals to increase competition among pests. It incorporates trees, hedges, and other diverse vegetation that filters water and facilitates infiltration into the groundwater. Sound ecologically based agriculture, or **agro-ecology**, attempts to mimic the natural environment. It evaluates agricultural systems in terms of ecological principals. Unlike industrial agriculture and its economic principals, agro-ecology taps the farmer's knowledge of his own land and matches this knowledge with scientific theory. Some of the techniques used by agro-ecology include: introducing plant communities similar to those found originally in the ecosystem; intercropping or poly-cultures, and; mechanical removal of insects. Ecologically based agriculture also works with the local hydrology by using silt deposited during floods or by using trees to regulate nutrients and stabilize the soils, and by cultivating healthy and abundant vegetation that helps keep soils moist and recharges the aquifer during those dry times. These approaches are effective in managing crop failure and offer greater disease resistance

Some examples of sustainable agricultural systems include:

Biodynamics. This system pays close attention to the interactions between animals and plants, between wild and managed ecosystems, and between the farmer and the extended environment.

Permaculture. This system combines water management, food production, energy supply, shelter, and wild space into land use and design. The objective is to enhance the well-being of humans and natural systems, while minimizing energy requirements and waste and maximizing both harvests and ecological integrity.

Eco villages. These systems meet community needs with approaches that include locally grown food, low transportation costs, and waste recycling. There are several functioning eco-villages in Sweden.

Ecologically Based Pest Management

Agriculture typically disrupts the natural environment. The use of chemicals initially kills pests such as weeds, insects, fungi, and pathogens. The problem with using chemicals is that pests can develop resistance to the chemicals, creating stronger more difficult pests. Many chemicals kill more than the problem pests and can kill or threaten the health of beneficial organisms, including humans.

Viable alternative approaches to chemical pest control minimize the damages from pests while promoting soil and plant health and water quality, without being too expensive. These alternatives study the emergence of pests in relation to other factors in the watershed and promote the production of pest control products that mimic natural processes and target specific pests. In general, alternative pest management approaches don't aim to completely eliminate pests. Instead they aim to reduce the damage. By doing so, alternative pest control enhances the ecological strengths of the watershed which ensures clean and plentiful water that can be stored in the watershed, including in groundwater, surface ponds, and soils.

Integrated pest management (IPM) is a form of pest control that uses natural predators to control pests. Ecologically Based Pest Management (EBPM) goes beyond IPM to incorporate ecological knowledge in order to decrease the rate at which pests develop resistance.

Sustainable versus Industrial Agriculture- point by poin

Industrial Agriculture
Assumptions
Nature is a competitor
Progress depends on larger and fewer farms
freedom
Progress = consumption
Profits = efficiency
Science is unbiased and produces a good outcome

General Approach
Singe focus on production
Large acreage
Powerful machines
Potent chemicals
Petrochemical fertilizers
Government subsidies to keep farms stable

Sustainable Agriculture
Assumptions
Integration of nature and agriculture
Local food systems support community autonomy and

Work with the local ecological conditions
Farmers are more in control of decision-making
Farmers are more self-sufficient
Strong farming communities

General Approach
Single focus is stewardship
Diversified and flexible production
Environmentally sound family farming
Reduces or eliminates use of chemicals
Intensive practices
Use of on-the-farm resources
Use of renewable energy
Conservation
Skillful adaptive management of natural processes
Builds soils through integration of live stock
Mechanically controls weeds

State Profiles

California

Water use and demand in California

Demographic trends in the West increasing California's residential water demands . At the same time, agricultural water use and demand is growing in California, despite reductions in farm size. Because water in California is controlled by markets, agriculture is struggling to compete with rapidly growing urban areas, hydropower, and more recently with the needs of riparian habitat and aquatic species. If California agriculture did not depend on the same mechanized water delivery system that supplies urban needs, it would not have to compete so directly for water. Future urban demand is driving the purchase of agricultural water rights because the return on water for recreation, tourism, and residential use is much higher.

One of the significant features of California's water resources is the disparity between where the water naturally occurs and where it is needed. Most of California's moisture falls in the northern half of the state and is stored as snowpack, while the majority of the population is in the south. Water is conveyed through an elaborate network of canals and tunnels from the northern to southern parts of the state. Another water supply challenge is that the state receives most of its rain between November and March with its highest demand occurring between May and September. This creates a need for water storage to supply water during dry periods. Because California is a coastal state, it also benefits from capturing rainfall runoff that would otherwise flow off the land and into the ocean where it is no longer useable. In the driest parts of the state, farmers have turned to groundwater supplies to access cheap and reliable water. However, these groundwater sources are rapidly being depleted.

In the 1700's water use was very low compared to today's level of use. Water was conveyed in ditches for irrigation. In the 1800's farmers built small dams and impoundment structures to store water for the dry times. By 1900 attempts to drought-proof agriculture led to an increase in large-scale water supply projects. San Francisco built a canal system to convey water from the Hetchy Hetchy Valley of Yosemite. Los Angeles did the same using the Owens Valley. In the 1920's Oakland constructed a tunnel systems to divert water from the Sierra Mountains. And in 1930 aqueducts were built across the desert to bring Colorado River water to southern California. The Central Valley Project of the 1930s and 1940s moved water from northern California to the agricultural lands of Central Valley. From 1950-1970 the California State Water Project established impoundment structures in the north to convey water to the southern California deserts. The development of this controlled water delivery system corresponded with the rise of an elite class of growers and business leaders that exercised total control over immigrant workers and small farms.

The drought of 1976-77 provides a vivid example of the importance of irrigated agriculture in California. When irrigated and non-irrigated losses are compared for this drought, non-irrigated cropland suffered 90% of the losses. In 1976 losses totaled $510 million and in 1977 losses totaled $800 million. Agriculture responds to drought in several ways: it can decrease acreage to save water; install more efficient irrigation systems; dig new wells; deepen existing wells; or simply accept smaller crops.

Agricultural Water Use California State Website Overview

Reproduced from: http://www.water.ca.gov/wateruseefficiency/agricultural/

"California's unique geography and Mediterranean climate have allowed the State to become one of the most productive agricultural regions in the world. The Sierra Nevada Mountain range that lines the eastern edge of the State capture and store winter precipitation that can be then used for summer irrigation in the Central Valley. This water, combined with the Mediterranean climate permits the growing of a great number of crops. California produces over 250 different crops and leads the nation in production of 75 commodities. California is the sole producer of 12 different commodities including almonds, artichokes, dates, figs, raisins, kiwifruit, olives, persimmons, pistachios, prunes and walnuts. "

"Most of this production would not be possible without irrigation. In average year California agriculture irrigates 9.6 million acres using roughly 34 million acre-feet of the 43 million acre-feet of water diverted from surface waters or pumped from groundwater. California's population growth and greater awareness of environmental water requirements has increased the pressure on California agriculture to use water more efficiently and to make more water available for urban and environmental uses. Decreasing agricultural water use is difficult for several reasons. First, California agricultural water use, when considered on a broad regional scale, for the most part, is very efficient. Individual fields and farms in some regions may have low efficiencies, but water that is not used on one farm or field is often used on a nearby farm or field. Secondly, for most crops, production and yield is directly related to crop water use. A decrease in applied water will often directly decrease yield. The key is management strategies that improve water use efficiency without decreasing yield.

There are technologies and management strategies available that conserve water while maintaining yield and production standards. These technologies and management strategies like improved irrigation scheduling and crop specific irrigation management often not only conserve water, but also save energy and decrease grower's costs. "

Below is a list of commonly used agricultural water conservation methods for both on-farm and district level implementation.

On Farm Water Conservation Methods
For a comprehensive list see:
http://www.twdb.state.tx.us/assistance/conservation/TaskForceDocs/WCITFBMPGuide.pdf

Irrigation Scheduling
Deciding when and how much water to apply to a field has a significant impact on the total amount of water used by the crop water use efficiency and irrigation efficiency. A number of different scheduling systems have been developed that can use either soil- plant or atmosphere-based measurements to determine when to irrigate. Using a more scientific approach to scheduling has generally been shown to decrease the amount of water applied while improving yield.

Tailwater Return Systems
To provide adequate water to the low end of the field, surface irrigation requires that a certain amount of water be spilled or drained off as tailwater. Tailwater return systems catch this runoff and pump the water back to the top of the field for reuse.

Irrigation System Improvements
Irrigation system improvement involves modifying the irrigation method or use of hardware and software to properly apply water to the field while minimizing water losses. For example improved furrows, combination of furrow and sprinkler, and changing from surface irrigation (flood, furrow and border check) to pressurized systems. Changing from surface irrigation to pressurized systems (sprinkler, drip, micro-irrigation) generally increases irrigation distribution uniformity and decreases applied water, although with certain soil types and applications, surface irrigation can be very efficient. In California there has been a trend to shift from surface irrigation to pressurized systems.

California food production
Food Facts

California has been the number one food and agricultural producer in the United States for more than 50 consecutive years.

More than half the nation's fruit, nuts, and vegetables come from here.

California is the nation's number one dairy state.

California's leading commodity is milk and cream. Grapes are second.

California's leading export crop is almonds.

Nationally, products exclusively grown (99% or more) in California include almonds, artichokes, dates, figs, kiwifruit, olives, persimmons, pistachios, prunes, raisins, clovers, and walnuts.

From 70 to 80% of all ripe olives are grown in California.

California is the nation's leading producer of strawberries, averaging 1.4 billion pounds of strawberries or 83% of the country's total fresh and frozen strawberry production. Approximately 12% of the crop is exported to Canada, Mexico, United Kingdom, Hong Kong and Japan primarily. The value of the California strawberry crop is approximately $700 million with related employment of more than 48,000 people.

California produces 25% of the nation's onions and 43% of the nation's green onions.

Source: http://www.beachcalifornia.com/california-food-facts.html

The Midwest

Agriculture and Water in the Midwest. The Midwestern United States receives relatively low rainfall, about 20 inches annually with 75% of the rain falling between April and September. Elevation is between 2000 and 4000 feet. The region is somewhat remote, resulting in high transportation costs. Frosts are common during the growing season. The region has grown to depend on the Ogallala Aquifer for a consistent water supply. Reports that the Ogallala is being drawn down have increased pumping levels to ensure the biggest yields before shortages occur.

Agricultural History of Kansas

In the late 1800s farmers were in search of fertile land. Around 1880 Kansas was experiencing a string of wet years that attracted an influx of settlers who tried planting a familiar, productive, wet-weather crop - corn. Because the state did not have natural sources of consistent flowing water and irrigation systems were not yet developed, farmers were completely dependent on rainfall. A few drier years nearly wiped out these new farmers, who tried planting heartier crops such as wheat and sorghum. Between 1910 and 1920 "war wheat" dominated the market in response to the new demands created by World War 'I. Over production after the war created a wheat glut, prices fell, and farmers were once again struggling. Between 1914 and 1929 farm production grew significantly (in order to keep up with falling prices) through mechanization and the use of the disc plow. The success of Kansas farming had a significant downside though: unprotected fields, drought and high winds which brought about the Dust Bowl of the 1930's. World War II and some healthy rains ended a decade of struggle with renewed demand and government price supports to buffer farmers if they overproduced. By 1950 production of wet weather dependent crops such as sugar beets and corn were almost completely eliminated from production and farms became specialized in wheat and sorghum. With the rise of specialization came the rise of technology - machines, chemicals (pesticides, herbicides, and fertilizers), hybridization, and increasing dependence on the Ogallala aquifer. Large diesel pumps were developed that could draw water from increasingly greater depths. These pumps were used to develop the center pivot irrigation system which grows crops in uniform circles using Ogallala groundwater. This flexible and reliable growing system has facilitated re-diversification of crops in Kansas to include soybeans and once again, corn. Because of the increase energy costs associated with the use of these pumps, water conservation (through pumping reduction) is driven more by energy prices than by aquifer draw-down issues.

Kansas Livestock History
Reproduced from: http://www.kshs.org/research/topics/agriculture/livestock.htm

"The livestock industry in Kansas has long been one of the most important aspects of the state's agricultural economy. Cattle drives, packinghouses, and large ranches are a significant part of this picture. Although this phase of the industry has been given a great deal of attention, raising and caring for various kinds of animals has long been a vital part of the general farm industry. In fact, mixed farming (grain-livestock) has always been the predominant form of agriculture in the state. Cows, chickens, hogs, and, of course, horses and mules have their own special place in the history of the family farm."

Cattle Drives
Joseph McCoy and others led the way in making several Kansas towns railheads for Texas cattle drives during the years following the Civil War. In 1867 Abilene became the state's first major cattle town.

Thousands of head of cattle were shipped on trains from railheads in Kansas to packing plants in Kansas City, Chicago, and other cities to the east. Between 1867 and 1885, towns like Abilene, Ellsworth, Wichita, Newton, and Dodge City became famous for their place in this industry.

Caldwell, located on the Kansas-Oklahoma border south of Wichita, was also an important railhead. This photograph show the Caldwell main street, circa 1900, shows Caldwell to Chicago on the Rock Island line.

Ranching
"The Great Blizzard" of January 1886 hastened the transformation of the cattle industry in Kansas. Cattle, which reportedly drifted for hundreds of miles during the storm, died by the tens of thousands. The losses on some ranches in the main storm areas were as high as 80 percent. In the wake of this great disaster, many ranchers decided that the open range system would no longer work in Kansas.

Once the buffalo had been hunted to near extinction and the long drives had come to an end, Kansas became one of the country's leading cattle states. The state ranked third in the nation in cattle population by 1890, a position it held for several decades.

With the closing of the open range, Kansas cattlemen began to place greater emphasis on the breeding of better stock. Shorthorns and Herefords were popular in the 1890s. One rancher to work for better stock was Frank Rockefeller, the brother of John D. Rockefeller of Standard Oil. He owned a Kiowa County cattle ranch of over 12,000 acres which specialized in purebred Herefords.

To protect their interests from threats posed by rustlers and homesteaders, ranchers formed large stock growers associations. These organizations gave the big cattlemen considerable control over the industry.

In addition to the large scale ranchers, medium sized and small farmers throughout the state contributed to the growth of the beef cattle industry.

Hogs
Hogs were also a very important part of the overall livestock industry in Kansas. In 1885, the state's hog population reached 3 million head. This meant that there were more than two pigs for every person in the state.

For many years, butchering hogs in the fall of the year was an important farm activity. It often became a community or neighborhood project.

Cattle

Although the cattle boom attracted the most attention, sheep were also becoming an important part of the Kansas livestock industry during the 1870s and 1880s. Stock sheep numbers reached an all time high in 1884,1,270,000 head. During the first half of the decade, the population of sheep in the state exceeded that of humans.

Dairies

Dairying was also important. Larger, more specialized dairy farms would become common later, but during the early years virtually every farm had at least one milk cow. Farm women often supplemented the family income by selling extra butter to local merchants. In 1884, nearly 24 million pounds of butter were produced. Before the end of the decade, there were over 650,000 milk cows on Kansas farms.

Work Animals

Work animals made up a vital segment of the livestock population on all farms well into the 20th century. Although oxen were fairly common in the 19th century, horses and mules were the primary source of power.

Poultry

Poultry products were also important to the Kansas farm economy. In 1903, nearly 6.5 million dollars worth of poultry and eggs were sold by producers throughout the state.

Florida

Source: http://www.floridaagwaterpolicy.com/PDF/Florida_Agricultural_Water_Policy_Report.pdf

Until the 1850's Florida agriculture primarily produced beef and citrus. Through the 1900's an elaborate network of canals was built to drain Florida's southern wetlands, creating a fertile agricultural area that increased total agricultural land to half the area of the state. Today Florida's 35 million acres of land includes 18 million acres is used for agriculture and forestry. Agriculture is the second most important industry in the state behind tourism. Agriculture provides the state with many benefits and services including: wildlife habitat; absorption of excess rainwater that reduces flooding impacts and enhances aquifer recharge; wetlands preservation; soil conservation; green space that breaks up sprawling urban areas, helping to reduce air and water pollution.

The most important crops include:

- Citrus- Florida produces the largest number of citrus products in the US and is #1 in orange and grapefruit production
- Horticulture- the state is #2 in the number of nurseries and greenhouse operations
- Aquaculture- the state leads the nation in production of tropical fish
- Livestock production- the state is a national leader in beef, poultry, and milk production
- Forestry- the northern half of the state supports commercial forestry
- Fresh vegetables- most of the countries fresh vegetables sold between January and March come from Florida

Florida agriculture faces numerous pressures from population growth. Annually the industry loses 150,000 acres to urbanization. This has elevated the importance of agriculture's role in maintaining an healthy hydrologic systems. Farms and ranches contain irrigated (8.2% of agricultural lands) and non-irrigated production lands and open land in its natural condition (which is typical for most agricultural lands).

The fact that natural forests and citrus groves both facilitate aquifer recharge is a good example of how agricultural water use provides many of the services that a natural system provides. A well managed agricultural operation can also provide additional benefits by receiving and using municipal wastewater as fertilizer or by storing floodwaters on-site and selling the water for aquifer recharge.

In 2000 agriculture accounted for 48% of freshwater use and is considered the largest water user. About 50% of the water used is returned to the system through aquifer recharge and flows that return to rivers and streams. Efforts to reduce water use through conservation and improvements in the efficiency of water use have resulted in annual savings of 90 billion gallons in 2001 in the citrus industry alone. Other agricultural operations such as nurseries, vegetable and fruit operations are also reducing water use by through new technology and recycling.

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